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Torrey Botanical Club

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THE OLDEST BOTANICAL JOURNAL OF THIS HEMISPHERE
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BULLETIN OF THE TORREY BOTANICAL CLUB

VOL. 88, No. 6, pp. 387–396 NOVEMBER, 1961

Convergent patterns of variation in *Ruellia caroliniensis* and *R. humilis* (Acanthaceae)[1]

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LONG, ROBERT W. (Ohio Wesleyan U. Delaware, O.) Convergent patterns of variation in *Ruellia caroliniensis* and *R. humilis* (Acanthaceae). Bull. Torrey Bot. Club 88 (6): 387–396. 1961.—*Ruellia* is a genus of approximately 225 species widely distributed in the tropics. Two species found in northeastern U. S. are *R. caroliniensis* (Walt.) Steud., and *R. humilis* Nutt. The species are homoploid with $n = 17$. The purpose of this investigation was to examine the relationship of these species in a four state area where they are sympatric. Variation patterns were determined from herbarium collections and transplants grown in the greenhouse. Overlapping variation was detected involving diagnostic characters used to discriminate between them. The species can be hybridized and possibly natural hybridization is a factor in causing the observed morphological intergradation. *Ruellia caroliniensis* and *R. humilis* are probably elements of the same biological species.

Ruellia is a large genus of mostly perennial herbs found primarly in the tropics and subtropics. About 225 species have been described making the genus second largest in the family Acanthaceae. Only 25 species are known to occur in North America. These plants are characterized by having erect or decumbent stems bearing opposite leaves, conspicuous blue or lavender 5-lobed axillary flowers and less conspicuous cleistogamous flowers. The species that occur in the United States belong to the section Dipteracanthus as classified by Lindau (1895). They have been treated in traditional monographic fashion by Fernald (1945) and Tharp and Barkeley (1949). Although Fernald did much to clarify the nomenclature of eastern species, his classification resulted in a complex system involving 18 varieties and forms in the two closely related species *R. caroliniensis* (Walt.) Steud. and *R. humilis* Nutt. Little use has been made of these names because varieties and forms are connected broadly by intermediates and apparently have slight geographic correlation (*cf.* Gleason, 1952; Shinners, 1958). Moreover, the identification of plants as either *R. caroliniensis* or *R. humilis* is frequently a difficult task particularly in those regions where they are

[1] Received for publication February 1, 1961.

This investigation was aided by a grant from the Research Fund of Ohio Wesleyan University. I wish to thank the collectors listed in Table 1 for their help in securing *Ruellia* plants.

I wish to thank the curators of the following herbaria for loan of specimens: Indiana University, The Ohio State University, Ohio University, University of Cincinnati, University of Kentucky, and University of West Virginia.

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sympatric. According to various authors, their principal morphological differences may be summarized as follows:

Leaves petioled, petioles up to 2 cm. long, floriferous nodes mostly 1 to 3, stems mostly simple ..... *R. caroliniensis*

Leaves sessile or subsessile, floriferous nodes mostly 4 to 8, stem branching near base ..... *R. humilis*

The purpose of this investigation was to examine the relationship of

Fig. 1. Distribution of *Ruellia caroliniensis* (solid line) and *R. humilis* (dotted line). Circles indicate sources of transplants.

these species in a four state area where they are sympatric and to test the present criteria by which they are separated in taxonomic keys. The facts outlined in the following discussion indicate kinds of problems needing solution before any precise delimitation of these species can be made.

DISTRIBUTION AND ECOLOGY.—*Ruellia caroliniensis* occurs in moist or dry woods, rocky soils, rocky bluffs, old fields, pinewoods, fencerows and waysides from New Jersey west to southern Ohio, Indiana and Illinois, south into Texas and Florida (fig. 1). It is highly variable in pubescence of capsule and stem, petiole length, number of floriferous nodes, and sizes of flower and leaf. Fernald (*loc. cit.*) called it the most baffling species of *Ruellia* in eastern United States. Chasmogamous flowering begins in late May and continues through July and early August. Cleistogamous flowers are produced later. Many herbarium collections of this species are incorrectly labeled *R. parviflora* (Nees) Britton or *R. ciliosa* var. *parviflora* (Nees) Gray.

Ruellia humilis is found in dry prairies, open woods, sandy soil, gravelly slopes, and waysides from Pennsylvania west to Minnesota, south to Texas, Alabama, and Virginia. It is highly variable, especially in sizes of flower and leaf, petiole length, pubescence of stem, and branching. Both chasmogamous and cleistogamous flowering generally coincide with that of *R. caroliniensis*. Numerous collections in herbaria of *R. humilis* are incorrectly labeled *R. ciliosa* Pursh.

PROCEDURE.—Comparisons and measurements were made of herbarium collections from Indiana, Kentucky, Ohio, and West Virginia. This four-state area comprises a large portion of that region where the two species are sympatric. Measurements were made on individual plants for internode lengths, numbers and arrangement of floriferous nodes, branching, leaf blade length and width, and petiole length. Indentical measurements were made with transplants grown in the greenhouse. These plants, with one exception, were obtained from regions where the two species do not occur together. Table 1 lists the plants and their sources. Voucher specimens are deposited in the herbarium of Ohio Wesleyan University.

TABLE 1. **Ruellia** *greenhouse cultures.*

Species	Culture number	Collector	Source
caroliniensis	35	J. T. Baldwin	York Co. Va.
"	53	R. E. Woodson	Rowan Co. Ky.
"	60	R. K. Godfrey	Columbia Co. Fla.
"	78	J. T. Baldwin	Charles City Co. Va.
"	95	R. K. Godfrey	Gadsden Co. Fla.
"	96	J. D. Ray	Hernando Co. Fla.
humilis	12	G. S. Winterringer	Hancock Co. Ill.
"	13	K. E. Bartel	Will Co. Ill.
"	23	K. E. Bartel	Grundy Co. Ill.
"	43	R. E. Woodson	Clay Co. Ill.
"	44	T. C. Lacey	Shelby Co. Tex.

Cytological studies were made on a representative plant of each species and chromosome number and behavior were observed. Flower buds were fixed in 3: 1 absolute alcohol-propionic acid solution for 24 hours, followed

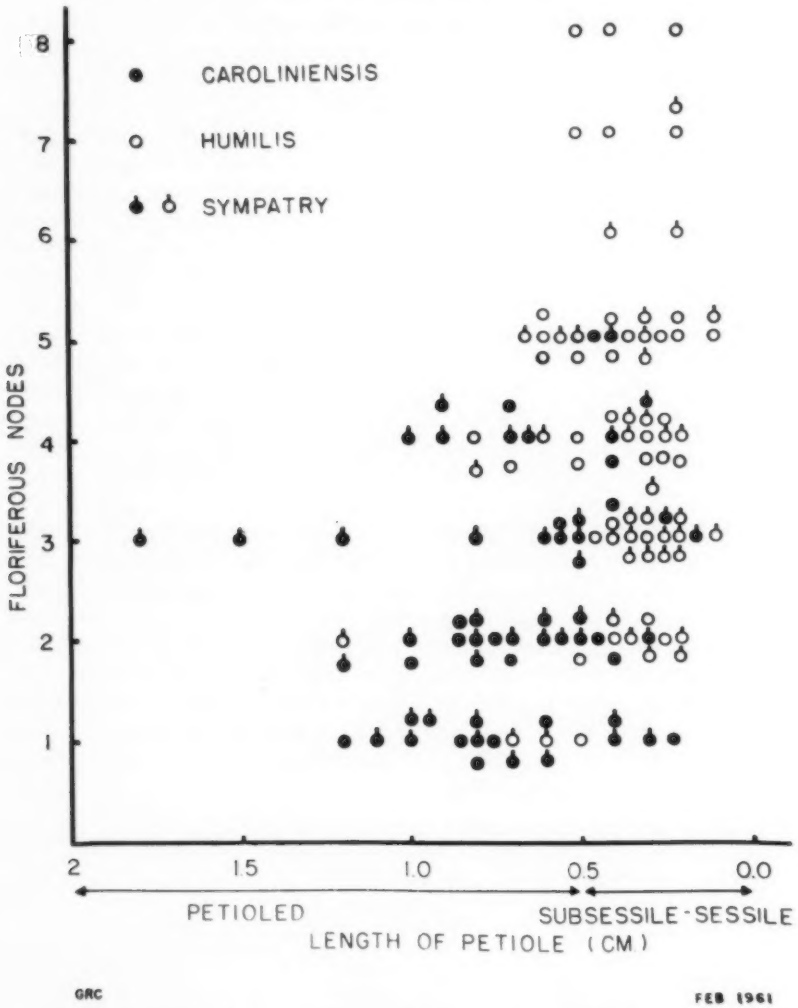


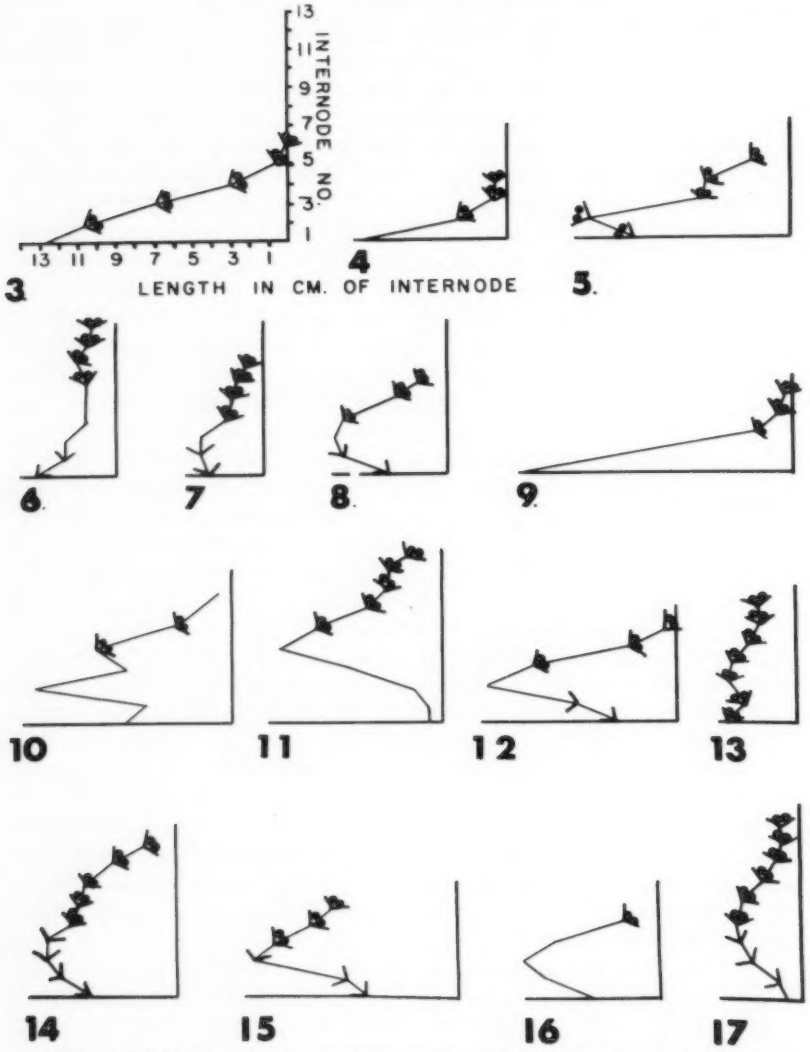
Fig. 2. Pictorialized scatter diagram of herbarium collections of *Ruellia caroliniensis* and *R. humilis*. Horizontal axis: length of petiole in cm. Vertical axis: number of floriferous nodes. Glyph with vertical ray indicates that specimen came from area where species are sympatric.

by transfer to 70% alcohol for storage. Anthers were smeared in Macullum's iron propionocarmine. Coverslips were then ringed with beeswax for temporary mounts. Slides prepared in this way were usable for approximately one week. Camera lucida drawings were prepared from selected cells.

Hybridization experiments were carried out using all races of the species available. These plants are self-compatible and emasculation of the flower used as the female parent is necessary for controlled pollinations. The corolla with attched stamens was removed as the flower opened in the early morning. Considerable care is necessary to insure that anthers do not accidentally brush against the stigma. Pollination was effected by removal of a stamen, using forceps, from the male parent plant and touching the dehisced anther to the stigma. The flower of the female parent was not bagged or otherwise protected since the crosses were carried out in the greenhouse where no pollinators were present. Early capsule formation was detected in a few days and mature fruits were present in approximately 4–5 weeks. Normal capsules are from 10–15 mm. long and contain up to 9 seeds. Abnormal capsules were less than 10 mm. long and were usually shriveled. Good seeds were plump and each contained a normal embryo. Aborted seeds, although of normal size, were flattened and had only a shriveled embryo. Occasionally some ovules failed to develop in an otherwise normal, mature capsule.

RESULTS.—After scoring herbarium collections for numbers of floriferous nodes and petiole lengths, the results were plotted on a scatter diagram (fig. 2). Vertical rays on glyphs indicate those plants which came from areas of species overlap. Generally, *R. caroliniensis* plants produced leaves with petioles 0.5–1.5 cm. long and stems bearing 1–4 floriferous nodes. *Ruellia humilis* plants produced leaves with petioles 0.1–0.4 cm. long and stems bearing 4–8 floriferous nodes. Approximately 40 per cent of all herbarium collections examined showed some degree of overlapping variation. Intergradation of these supposedly significant diagnostic characteristics is readily apparent and accounts for much of the taxonomic difficulty in the identification of these species. Evidence does not support a conclusion that intergradation occurs just in regions of sympatry, however.

The next step was the examination of the relationship of plant habit, as determined by internode patterns, to branching and arrangement and production of flowers. Initially, and on the basis of observations of transplants, I thought it possible to distinguish the species by using internode patterns. Ideographs, similar to those used by Anderson and Schregardus (1944), show proportional lengths of successive internodes and relative positions of flowers and branches (figs. 3–17). They were constructed for all greenhouse transplants and herbarium collections. Generally, these ideographs fall into three groups: (1) *R. caroliniensis*, because of its comparatively long initial internodes and very short ultimate and penultimate



Figs. 3–17. Ideographs of transplants and herbarium specimens showing internode patterns, branching, and arrangement and production of flowers. Horizontal axis: length of internodes in cm. Vertical axis: internode number. Solid circles: flowers. Rays: branches. —Fig. 3. *R. caroliniensis* #53. —Fig. 4. *R. caroliniensis* #95. —Fig. 5. *R. caroliniensis* #35. —Fig. 6. *R. humilis* #13. —Fig. 7. *R. humilis* #23. —Fig. 8. *R. humilis* #43 —Fig. 9. *R. caroliniensis*, Lawrence Co. Ohio (OS). —Fig. 10. *R. caroliniensis*, Miami Co. Ohio (OS). —Fig. 11. *R. caroliniensis*, Jasper Co. Ind. (IND). —Fig. 12. *R. caroliniensis*, Wood Co. W. Va. (WVA). —Fig. 13. *R. caroliniensis*, Lafayette Co. Ind. (IND). —Fig 14. *R. humilis*, Champaign Co. Ohio (OS). —Fig. 15. *R. humilis*, Woodford Co. Ky. (KY). —Fig. 16. *R. humilis*, Highland Co. Ohio (OS). —Fig. 17. *R. humilis*, Lawrence Co. Ind. (IND). Explanation in the text.

ones, is represented by ideographs strongly skewed to the right, unbranched, and bearing 3–5 floriferous nodes (figs. 3, 4, and 5). Many herbarium specimens showed similar patterns, as typified by fig. 9. (2) *R. humilis* plants have comparatively short initial internodes, followed by still shorter ones. Ideographs of greenhouse plants are nearly vertical or slightly skewed to the right, repeatedly branched and bearing 3–4 floriferous nodes (figs. 6, 7, and 8). (3) A third group of ideographs includes an assortment of discordant forms in which no particular variation pattern is evident. Some herbarium collections of *R. caroliniensis* showed a pattern strongly suggestive of *R. humilis*, as in fig. 13. Similarly, some herbarium collections of *R. humilis* gave ideographs strongly arched to the right, resembling *R. caroliniensis* except for conspicuous branching. Generally, collections of *R. humilis* were as in fig. 17, a form resembling the transplants of that species. The ideograph of fig. 10 is taken from a collection of *R. caroliniensis* collected 150 miles north of its range in Ohio. It approximates ideographs of a morphologically unrelated species *R. strepens* L., which is common in the Midwestern States.

The results of hybridization experiments involving different races and varieties of *R. caroliniensis* and *R. humilis* are summarized in table 2. Normal fruit formation and seed production is high in interracial and intervarietal crosses. Results indicate that approximately the same results are

TABLE 2. *Artificial hybridization experiments in* **Ruellia**

Species	#	Capsule formation		Good seeds		Aborted seeds		Undeveloped ovules	
		normal	abnormal	4–9	1–3	4–9	1–3	4–9	1–3
caroliniensis × *caroliniensis*	♀ × ♂								
	35 × 53	X		X			X		
	35 × 95	X			X	X			
	60 × 60		X				X		
	78 × 35	X		X			X		
	78 × 78	X		X					
	78 × 95	X			X	X			
	95 × 78	X		X		X			
	95 × 95	X		X					
	96 × 35	X		X		X			
	96 × 95	X		X					
caroliniensis × *humilis*									
	12 × 35	X		X				X	
	12 × 95	X			X				
	35 × 12	X		X		X			
	35 × 23	X		X					
	35 × 43	X		X			X		
	35 × 44	X		X			X		X
	44 × 95	X			X				
	78 × 23	X					X		X
	78 × 44		X						
	95 × 12	X		X					

obtained in interspecific crosses. Since good seeds contained normal embryos, they presumably would germinate to produce the F_1 hybrids.

Some observations have been made of pollen mother cells. Both species have a haploid count of 17 chromosomes. Grant (1955) reported $2n = 34$ for the species from root tip cells. Normal bivalent formation occurs during meiotic prophase I. Meiosis proceeds normally although a few cells contained inversion figures (fig. 18).

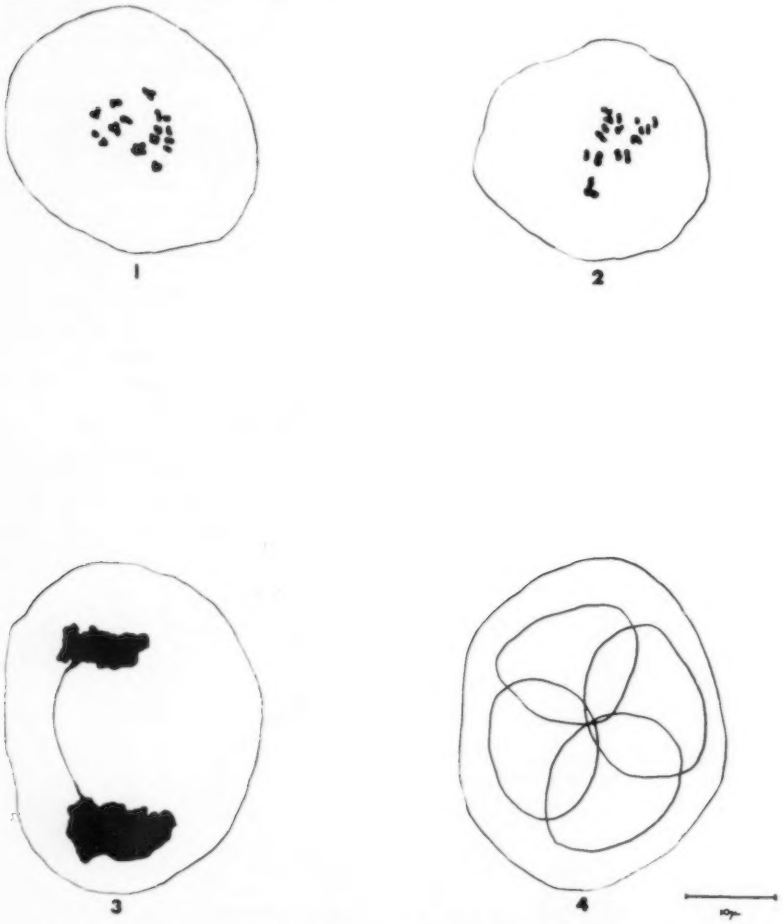


Fig. 18. Microsporogenesis in *Ruellia*:—18–1. Diakinesis, with 17 bivalents in *R. caroliniensis* #96;—18–2. Diakinesis, with 17 bivalents in *R. humilis* #12;—18–3. Telophase I with chromatid bridge in *R. caroliniensis* #96;—18–4. Normal tetrad formation in *R. carolinicnsis* #96.

CONCLUSIONS.—Although biosystematic investigations of *Ruellia* are still in early stages, some conclusions regarding the taxonomy of *R. caroliniensis* and *R. humilis* have been developed:

1) Before any revision of sections of the genus is attempted, a thoroughgoing study must be made of the reproductive biology of species. This problem has been consistently overlooked in past work. Both species produce both chasmogamous and cleistogamous flowers and both kinds of flowers produce spontaneously normal fruits with good seeds. Observations confirmed that aestival cleistogamous flowers occur on the same individual plants as do vernal chasmogamous flowers. Generally, in higher plants one means of reproduction predominates over any others, but in *Ruellia* we are not certain whether plants in the field reproduce primarily through outbreeding or inbreeding. Circumstantial evidence suggests that the plants reproduce nearly completely by inbreeding, for pairs of populations tend to be clearly distinguishable. Field studies made thus far, in the Carolinas and in southern Ohio, indicate that within local populations there is little or no plant-to-plant variability.

2) Hybridization experiments suggest that internal barriers to interspecific crossing are lacking between *R. caroliniensis* and *R. humilis*. This demonstrates the necessity of a broad program of hybridization experiments to determine crossing relationships in *Ruellia*. *Ruellia caroliniensis* is probably one of a complex of closely interrelated eastern species.

Since the species are interfertile, natural hybridization is one explanation for the variation patterns observed in herbarium collections. The intergradation of morphological characters used to differentiate the species could be caused by introgression of genes from one species into the genetic material of the other. Field studies, however, have not resulted in the discovery of any hybrid populations. It is possible that the apparent intergradation is brought about fortuitously by environmental factors. It is also possible that spatial isolation of local populations, together with habitual inbreeding, might lead to the evolution of distinctive characters within these populations. This variation could be in the direction of that of the other species, again fortuitously. Additional field work is necessary before these three explanations can be adequately tested. The evidence tends to support natural hybridization as an important cause of intergradation because of the lack of strong ecological differences between the species, sympatry, coincidence of flowering, and weak internal barriers to crossing.

3) The morphological analysis of herbarium collections and greenhouse transplants leads to the conclusion that petiole length and numbers of floriferous nodes show patterns of convergence and overlap in the two species. That these characteristics are genetically controlled was demonstrated by observations of transplants. Similarly, each species has a characteristic habit determined by internode, branching, and flower production

patterns. Transplants of one species were clearly separable from those of the other on the basis of plant habit. Some herbarium specimens of one species had the general habit of the other, or showed a habit unlike either species. Thus, both convergence and discordance occur in the variation patterns of the two species.

The most essential property of a species is its ability to maintain a characteristic morphology in areas of sympatry with related species (Grant, 1957, p. 47). If this is true it follows that *R. caroliniensis* and *R. humilis* are elements of the same biological species since they intergrade morphologically and can be hybridized. These two "taxonomic species" would then be considered as geographic subspecies of a large, polytypic "biological species". Only additional work can determine just how inclusive this biological species is.

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Growth determination in *Hydrodictyon*[1]

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MCREYNOLDS, JOHN S. (Harvard Medical School, Boston, Mass.). Growth determination in *Hydrodictyon*. Bull. Torrey Bot. Club **88(6)**: 397–403. Illus. 1961.—The experiments reported here indicate that the direction of growth in *Hydrodictyon reticulatum* is determined by pressure, and that no growth occurs without pressure. Once the direction of growth has been determined, it continues in the same direction when all external stimuli are removed. This period of determination is of fairly short duration, approximately one day in length. Two types of asexual swarming were observed in 2 different clones of *Hydrodictyon*, corresponding to the two conflicting descriptions of the swarming process found in the literature.

In the freshwater alga *Hydrodictyon reticulatum*, the usual method of reproduction is asexual. During the night, the protoplasm of the multinucleate cell undergoes a series of cleavages which divide it into several thousand uninucleate zoospores. The biflagellate zoospores remain still until shortly after daybreak, when they begin to move slowly back and forth. Then all the zoospores are drawn toward the center of the cell where they form a dense column. After a short time, they break loose from this column and swim about freely inside the mother cell, eventually reaching the cell wall where they slow down and come to rest in a layer along the wall, leaving a netlike arrangement of zoospores which soon begin to grow. The mother cell wall disappears and the young net grows to a length of 20–50 cm. by elongation of the cells. The new net is thus shaped like the mother cell within which it was formed.

Less frequently sexual reproduction is observed. Cleavage of the mother cell produces a large number of motile gametes which escape into the surrounding water. The gametes fuse to form a resistant zygote. On germination, the zygote gives rise to four motile spores by meiosis. The spores each form an angular structure known as a polyeder, within which zoospores arise by cleavage. These zoospores swarm within the now swelling polyeder and form a disc-shaped net. It is not known what molds the shape of this net, although Moner (1953) has recently presented evidence that the size and shape of an inner vesicle plays an important role in the guidance of a similar plate development in the related *Pediastrum*. Since this flat net consists of cylindrical cells, the young nets arising from it asexually will also be cylindrical.

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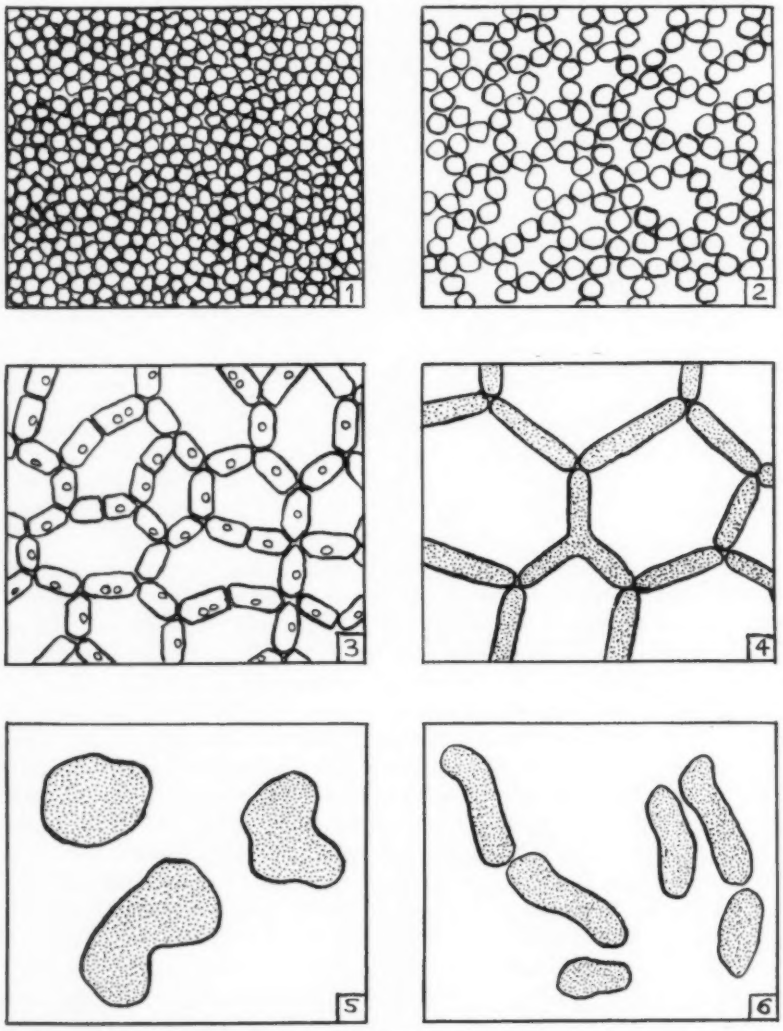
Before asexual swarming, the zoospores are tightly packed along the mother cell wall where they were formed by cleavage of the protoplasm (fig. 1). After swarming, the zoospores return to the cell wall, but are now



Figs. 1–6. Growth determination in *Hydrodictyon*.—Fig. 1. Zoospores on mother cell wall before swarming. 1385X.—Fig. 2. Zoospores immediately after swarming showing the outline of the future net. 1385X.—Fig. 3. Portion of a net about one day old showing the elongation of the cells. 1040X.—Fig. 4. Portion of a mature net showing a 3-armed cell. 14X.—Fig. 5. Cells grown from zoospores under agar. 70X.—Fig. 6. Seven day old cells which were implanted in agar when one day old. 83X.

more loosely arranged, with numerous intercellular spaces (fig. 2). Harper's (1908) explanation for the looser arrangement is a shrinking of the protoplasm. These intercellular spaces form the future meshes of the net, whose structure is already visible at this stage even though the zoospores are still spherical. The round zoospores, 6–7 μ in diameter, soon begin to grow and become first elliptical, then sausage-shaped (figs. 3 & 4), eventually reaching a length of 1.5–3 mm.

One can see that the zoospores elongate where they are in contact with their neighbors. The effect is to enlarge the meshes by lengthening the sides. If a zoospore is situated so that it makes contact with others at three or four separate places on its surface, then it grows not cylindrically, but with three or four arms (fig. 4).

According to Harper, zoospores which touch only one other zoospore grow shorter than normal, and those that touch no others do not grow at all. He uses these facts, along with other evidence, to support his idea that the zoospores grow in response to pressure. Furthermore, he noted that the growth axis of the cell bore no relation to the long axis of the zoospore, which is determined by the ciliated front end. He pointed out that if the cells grew in the direction of greatest resistance they would tend to meet in groups of three at angles of 120°, and upon measurement found this to be the most frequent arrangement.

It is obvious that contact with their neighbors determines the shape of the cells; this is the only possible way in which such a net structure could be formed. But there are several ways in which contact could influence cell growth. In addition to his pressure stimulus, Harper also mentions a few other possibilities. Perhaps the zoospores receive chemical stimuli from adjacent cells at the points of contact. The areas of contact also differ from the exposed surfaces in ability to take in food and get rid of internal products, both of which might locally affect growth.

There is one basic disagreement in the past work on the growth of *Hydrodictyon*. Harper implied that the zoospores will not grow without contact, which determines the growth axis of the cell by functional hypertrophy. Jost (1930) performed experiments to check the work of Harper and others, and came to the conclusion that the zoospores would not only grow when isolated, but could assume their elongate shape without external guidance. He claimed that the isolated zoospores elongate along their own long axis, but that this polarity was altered by the contact stimulus from other cells when in the net, resulting in the same final cell shape.

Evidence will be presented to show that growth in zoospores is initiated and determined by pressure, and that once determined, it can occur withut any external guidance.

MATERIALS AND METHODS.

1. All algae used in the experiments were from one clonal stock obtained from a single cell.

2. The algae were grown in a culture medium (henceforth referred to as standard nutrient) consisting of 1 part earth extract to 4 parts Uspenski solution (see Neeb, 1952). The earth extract was prepared by autoclaving 80 g. earth with 1 liter tap water and filtering the resultant solution. The same batch was used for all experiments.

3. According to Pirson (1957), *H. reticulatum* requires a regular alternation of light and darkness for normal development, and characteristic growth anomalies appear after a few days if the nets are grown under constant light. The algae were therefore grown under alternating 12 hour light and dark periods. Neeb (1952) reported an optimum growth in *Hydrodictyon* at a light intensity of 100 foot-candles. Although he noted deformities of the net at intensities above 80 f.c. in winter and above 30 f.c. in summer, our algae were grown at 100 f.c. without deformities. An intensity of 150 f.c. was tested and resulted in deformities in many cells. The 100 f.c. used in the experiments was obtained from one 40W daylight fluourescent bulb and one 60W incandescent bulb at approximately 2 ft.

4. The average temperature of the culture was 22° C. in dark, and 27° C. in light.

5. To obtain isolated zoospores in agar, a cell was cut open while swarming was in progress and the zoospores were sucked out with a micropipette. They were immediately blown out of the pipette into the solidifying agar (about 38° C.). The entire transfer process took less than fifteen seconds.

RESULTS.

Isolated zoospores in liquid.—Several thousand swarming zoospores were removed from the mother cells in a series of separate experiments and placed in flasks containing standard nutrient. The zoospores tended to aggregate in clumps but never grew. Within two or three days after the zoospores were put into the solution they all disappeared.

Isolated zoospores under agar.—Fourteen experiments were run in which swarming zoospores were placed under 2% standard nutrient agar just before it began to solidify. About 1000 of these grew under the agar, although many times that number were implanted. The cells grown under agar were not generally cylindrical, usually growing out in all directions and giving very irregular shapes, although often they were roughly spherical (fig. 5). Growth up to a diameter of about 400–500 μ was observed in many cases.

Older cells isolated in liquid.—190 cells were isolated from growing nets and placed in flasks containing fresh nutrient. 12 of these cells, averaging 1.0 mm. in length and 0.08 mm. in width, were measured and each placed in a separate flask. After 7 days they were measured again and showed an average increase of 2.1 mm. in length and 0.12 mm. in width,

about 17 times as much increase in length as in width. The growth of the other 178 cells was not measured but on inspection they seemed to have grown to the same extent. To determine if the size of the cell was a factor in its ability to continue elongating, these cells were divided into 4 size groups ranging from 0.5–2.0 mm. in length. In only 2 of the 190 cells was any deviation from the normal shape observed, both in the 0.5–1.0 mm. group.

The behavior of these isolated cells is similar to cells remaining in the net, although the latter do not appear to elongate quite so rapidly. The exact growth of cells in the net was not measured due to the problem of identifying individual cells. In any case, the cells continue to elongate, whether in the net or removed from it.

Older cells isolated under agar.—59 already cylindrical cells were isolated and implanted in 2 percent nutrient agar. 10 of these were measured and after 7 days showed an average increase of 1.2 mm. in length and 0.09 mm. in width. This is about 13 times as much increase in length as in width. No departure from the normal cylindrical shape was observed in any of the 59 cells.

Isolation of cells less than one day old in liquid.—Newly formed nets less than a day old were gently ground up in a hand homogenizer and then put in flasks containing standard nutrient solution, which were inspected 7 days later. Most of the cells were destroyed in this operation, but those which survived continued to elongate. These were generally linked together in small groups. Only 28 completely isolated cells were observed and these also continued to elongate in the same manner as the linked ones. No deviations from the normal cylindrical shape were noticed.

Isolation of cells less than one day old under agar.—Newly formed nets were homogenized and placed under nutrient agar. After 7 days many of the cells had grown in a generally elongate fashion, although there were a great many deformities (fig. 6). The abnormalities occurred with about equal frequency in isolated cells and in groups of linked cells. Of 207 cells counted, 86 showed irregular growth and 121 were normal.

Further growth of irregular cells in liquid.—Approximately 200 abnormally shaped cells grown under agar were transferred to standard nutrient solution after they had ceased growing under the agar. Further growth followed, but no tendency to revert to a cylindrical shape was observed. Practically all of the cells reproduced asexually, forming nets of the same irregular shape as the mother cell.

A note on the swarming process.—During the course of these investigations, two types of asexual swarming were observed in the two clones used. In the clone used in the experiments described above, the zoospores were drawn to the center of the cell to form a dense mass and then released

to swim about, finally coming to rest on the inside of the cell wall. This is the way Harper (1908) describes the process. In another clone, used in other experiments on a different problem, the zoospores merely oscillated back and forth near their original positions, and then ceased motion without ever really swarming. This type of swarming was similar to that described by Klebs (1890) and Jost (1930). In both cases development was identical after swarming.

DISCUSSION.

These experiments indicate that contact in the form of pressure or resistance to growth determines the direction of growth in the zoospores of *Hydrodictyon reticulatum*, and that no growth can occur without this pressure. However, the pressure is a factor only in the early stages of growth. Once the direction of growth has been determined, it continues in the same direction after all external stimuli are removed.

Jost (1930) put zoospores under agar and observed that they grew into roughly elongate shapes with many distortions. His drawings of these shapes are similar to those obtained in this study (see fig. 6). He explained the deviations from normal shape as being due to local nutritional differences, and asserted that the zoospores were capable of elongating without any external guidance. According to his theory, in isolated zoospores the polarity of growth is determined by the axis of the zoospore itself, but when it comes into contact with other cells in the net, these points of contact alter the polarity so that growth in another direction results.

Although this theory accounts for the shape of normal as well as 3- and 4-armed cells in the net, it implies that some agent besides pressure is the determining factor if the pressure of the agar did not alter the polarity of the cell.

Zoospores grown under agar in the present experiments did not assume an elongate shape. While indicating that Jost's idea was not correct, this fact does not rule out the possibility that other agents besides pressure may be causing growth.

We know that contact alone is not enough to cause growth, for the aggregates of zoospores in experimental group 1 failed to grow. This eliminates the possibility of differential absorption and release of substances as a controlling factor. The possibility of a special stimulus from an adjacent cell through contact is also ruled out since isolated zoospores do grow under agar.

It seems fairly certain that pressure in the form of resistance to growth determines the direction of growth in the zoospores. The zoospores were examined in three types of environments: in clusters in liquid medium, under agar, and in the mother cell. In all three situations we have contact,

but only in the last two, which involve resistance to growth, do we actually get growth. There would be little pressure in the liquid aggregates since the mass is not confined and is free to expand.

The irregularities in the roundish cells grown under agar can be explained by the differential concentration of the agar around the zoospores, due to water brought in with them, the more concentrated areas offering greater resistance and causing more growth.

The period of determination is of fairly short duration. Cells placed under agar less than a day after they had swarmed already showed a tendency to continue elongating, although many of them were still influenced into new directions of growth by the pressure of the agar. It may be that Jost obtained results like this in the growth of his zoospores because he waited too long before removing them from the mother cell, so that their growth axes were already partially determined.

There are two other facts of interest that may, upon further investigation, show a relation to the period of growth determination. Neeb (1952) states the existence of a light-independent growth stage up to the first nuclear division, which is of roughly the same length as the period of growth determination. Jost (1930) has indicated that the young cells do not form cellulose walls until after the first day of growth.

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Studies on *Monilia sitophila* from Indonesia[1]

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DWIDJOSEPUTRO, DAKIMAH. (Dept. of Biology, Vanderbilt U., Nashville, Tenn.) Studies on Monilia sitophila from Indonesia. Bull. Torrey Bot. Club **88(6)**: 404–411. 1961.—Sixty years ago Went studied the fungus *Monilia sitophila* in west Java, where it occurs, in the conidial stage, as a constituent of ontjom, a condiment prepared from peanut press cake. Examination of cultures derived from ontjom obtained in Indonesia have now shown the existence of a perithecial stage with asci and ascospores of the type characteristic of *Neurospora*. Condia of the Indonesian isolate measure $11.3 \pm 1.6 \times 9.9 \pm 1.1$ μ. The ascospores measure $23.4 \pm 1.5 \times 15.4 \pm 1.2$ μ. These measurements, together with morphology of the perithecia and the findings from crosses with known strains, indicate that the Indonesian isolate is *Neurospora sitophila*.

A number of physiological observations were made on cultures of the Indonesian strains. The conidia are killed by 10 minutes exposure to 80° C, but not by a similar exposure to 70° C. Heat activation of ascospore germination occurs at temperatures of 50–56° C, maintained for 30 minutes or longer. At 54° or 56° C, but not at 50° or 52° C, percentage germination is greatly decreased by exposure longer than 70–80 minutes. The Indonesian isolate extends radially very rapidly on agar plates, but produces less dry weight in a liquid medium than other strains tested. The Indonesian isolate can digest casein, and its capacity for lipase production was greater than that of other strains examined.

Went (1901) reported the presence, in West Java, of the fungus *Monilia sitophila* (Mont.) Sacc., on ontjom, a condiment derived from the press cake of peanuts (*Arachis hypogaea* L.). Ontjom, which is prepared by allowing the mold to grow on peanut press cake for approximately 48 hours, forms an article in the daily diet of some 25,000,000 people. In studies of the mold pursued after his return to Holland, Went described the presence in his cultures of hyphal aggregates (Hyphenknäuelen) whose further development he was unable to secure regardless of the cultural conditions employed.

Shear and Dodge (1927) discovered the perfect or perithecial stage of strains of red bread mold fungi from Europe, North and South America, and erected for them the genus *Neurospora*, with four species: *N. sitophila*, *N. crassa*, *N. tetrasperma*, and *N. erythraea*. *N. sitophila* and *N. crassa* were

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found to be heterothallic, and perithecia containing 8-spored asci were produced only upon mating two compatible strains. *N. tetrasperma* and *N. erythraea* have 4-spored asci and *N. tetrasperma* is definitely homothallic.

Since the work of Shear and Dodge (1927) investigations on the ontjom-mold have been lacking (Boedijn, 1960). This paper presents the results of studies of a morphological, taxonomic, and physiological nature upon strains of *Monilia sitophila* isolated from ontjom.

MATERIALS AND METHODS. Crumbs of ontjom-cake from a food market in Bandung, Indonesia, received in December, 1959, were sprinkled onto potato dextrose agar plates. After 48 hours incubation, five colonies characterized by saffron pink conidia were isolated from the plates. Two of the isolates produced brownish protoperithecia which developed, after three weeks, into perithecia containing asci with 8 ascospores. One of these isolates (representing a mixed culture of two compatible strains) was propagated further without isolation of single spores, and regularly produced perithecia. The remaining three isolates failed to produce perithecia. Attempts to intercross the three in all possible combinations were futile. Two of these were discarded, and the remaining isolate was saved for further study.[3]

Distinctions among the species of *Neurospora* are based, in part, upon the dimensions of the conidia, perithecia, and ascospores. Consequently, the conidia and ascospores of the Indonesian material were measured and compared with known strains. Conidia for measurements were obtained from cultures grown for 2 days on corn meal agar. Ascospores resulting from the mating of compatible strains were obtained from cultures maintained on corn meal agar for one month. Each series of observations consisted of 250 measurements of length and 250 of width.

According to Shear and Dodge (1927), "In their conidial stage the two heterothallic species are not readily distinguished with certainty. The most practical way by which the species affiliations of the sterile cultures could be determined was to grow them in combination with monosporous cultures of known origin." Since the perithecia-producing cultures of the Indonesian isolates were found to have 8-spored asci, *N. tetrasperma* and *N. erythraea* were dismissed from consideration. Consequently, the following strains were obtained from the American Type Culture Collection, Washington, D. C.:

Neurospora crassa 10336. Mating type *A*.
Neurospora crassa 10337. Mating type *a*.
Neurospora sitophila 9276. Mating type *A*.
Neurospora sitophila 13349. Mating type *A*.
Neurospora sitophila 13350. Mating type *a*.

[3] This isolate has been deposited in the American Type Culture Collection, Washington, D. C., under the accession number 14151.

These cultures were grown on corn meal agar, and conidial measurements and ascospore measurements were made under the same conditions as described for the Indonesian isolates. Crosses between these strains and the Indonesian conidial isolate were made in an effort to determine the taxonomic status and compatibility group of the latter.

The heat resistance of conidia of the Indonesian isolate was determined by subjecting conidial suspensions in water in test tubes to temperatures of 50°, 60°, 70°, 80°, 90°, or 100° C. in a water bath for ten minutes. The tubes were quickly cooled and inoculations were made on plates of potato dextrose agar, which were examined for growth after 24 hours.

Since Shear and Dodge (1927) reported that heat treatment of ascospores was required for germination, this phenomenon has been studied by Faull (1930), Lindegren (1932) and others. It was of interest to attempt to determine the temperature and time requirements for ascospore germination of the Indonesian perithecium-producing strain. The method adopted after a number of preliminary trials was as follows: Six circles 0.5–1.0 cm in diameter were drawn on the outside of the bottoms of petri dishes containing corn meal agar medium, and ascospores were sown on the agar surface within the circles by means of a micropipette. One plate served as a control in each experiment, and 18 plates were placed at 50°, 52°, 54° or 56° C. in an electric oven for periods of 10 to 180 minutes. After 7 hours at room temperature, the plates were examined and the percentage of germination was recorded.

The growth of the Indonesian isolate was compared with that of other strains in the minimal medium of Beadle and Tatum (1945). The liquid medium was dispensed in 25 ml. quantities in 125 ml. Erlenmeyer flasks and was sterilized by autoclaving. After inoculation the flasks were placed on a rotary shaker operated at 150 r.p.m. After 8 days, the mycelial pellets were removed by filtration, dried in a desiccator over Drierite, and weighed.

In order to evaluate the capacity of the various strains to produce lipase, the fungi were grown in corn meal liquid medium for 5 days. The mycelial mats were removed, immersed in several changes of acetone for a few hours, dried, and ground to a powder. One hundred mg of the acetone powder preparation of each strain was placed in 10 ml of distilled water, and the mixture was allowed to stand for 2–3 hours to extract the enzyme. Ten ml of enzyme extract was added to a suspension of 1 ml of peanut oil, 9 ml of distilled water and 5 ml of a dilute gum acacia sol. After 48 hours at room temperature phenolphthalein was added as an indicator, and the contents of each flask were titrated with 0.02 N NaOH to determine the acidity resulting from fatty acids released by fat hydrolysis. A reagent blank served as the control.

Protein digestion was qualitatively observed by growing the strains on

plates of an agar medium containing 0.5 per cent powdered dehydrated milk, and observing the change in transparency resulting from casein digestion.

RESULTS.

Conidial and Ascospore Measurements, and Perithecia.—The results of the measurements of conidia of the various strains were as follows:

N. crassa 10337	$8.7 \pm 1.4 \times 8.4 \pm 1.2\ \mu$
N. sitophila 9276	$10.0 \pm 1.7 \times 8.9 \pm 0.8\ \mu$
N. sitophila 13350	$9.6 \pm 1.7 \times 7.6 \pm 0.9\ \mu$
Indonesian conidial strain	$11.3 \pm 1.6 \times 9.9 \pm 1.1\ \mu$

Measurements of ascospores following successful mating experiments may be summarized as follows:

N. crassa 10336 × *N. crassa* 10337	$30.8 \pm 1.5 \times 15.3 \pm 0.8\ \mu$
N. sitophila 9276 × *N. sitophila* 13350	$22.3 \pm 1.7 \times 12.8 \pm 1.6\ \mu$
N. sitophila 9276 × Indonesian conidial strain	$19.2 \pm 1.7 \times 10.6 \pm 0.9\ \mu$
Indonesian perithecial strain	$23.4 \pm 1.5 \times 15.4 \pm 1.2\ \mu$

The mature perithecium of the Indonesian strain is spherical, about 330 μ in diameter, and has a short neck. The perithecium of *N. crassa*, as described by Shear and Dodge (1927), is larger, more urn-shaped, and has a longer neck. The perithecia of the Indonesian strain agree well with the description of *N. sitophila* according to Shear and Dodge (1927), as well as with perithecia produced by crossing *N. sitophila* 9276 and *N. sitophila* 13350.

Crossing experiments.—Each experiment involved 5–10 plates and was replicated at least 4 times. The results were considered negative only when observations made two months later showed no perithecia. Crosses made during the summer months when the laboratory temperature occasionally reached 35° C. did not result in perithecium production at times even when compatible strains were mated. Similar observations have been made by Denny (1933). The results of the crossing experiments are presented in Table 1.

Heat resistance of conidia.—Conidia in suspensions exposed to 50°, 60°, or 70° C. for 10 minutes survived and developed into normal colonies. Those exposed to 80° C. or higher temperatures were killed.

Heat activation of ascospores.—Preliminary trials of heating ascospores of the Indonesian isolate by the methods of Shear and Dodge (1927) and Lindegren (1932) were unsatisfactory. For this reason, the procedure described in Materials and Methods was developed. Six experiments were done at 56° C., six at 54° C., two at 52° C., and two at 50° C. Approximately 45,000 ascospores were counted in these experiments.

TABLE 1. *Results of crosses involving strains of* ***N. crassa, N. sitophila,*** *and the conidial Indonesian isolate.*[a]

Strains	Production of protoperithecia	Production of mature perithecia and ascospores
N. crassa 10336 × ***N. crassa*** 10337	+++	+++
N. crassa 10336 × ***N. sitophila*** 9276	–	–
N. crassa 10337 × ***N. sitophila*** 9276	++	–
N. crassa 10337 × ***N. sitophila*** 13350	++	–
N. crassa 10336 × ***N. sitophila*** 13350	–	–
N. sitophila 9276 × ***N. sitophila*** 13350	+++	+++
Indonesian × ***N. sitophila*** 9276	+++	+++
Indonesian × ***N. sitophila*** 13350	++	+[a]
Indonesian × ***N. crassa*** 10336	–	–
Indonesian × ***N. crassa*** 10337	++	+[a]

[a] These crosses showed a very inconstant fertility. Hundreds of perithecia were examined, but no more than sixty ascospores were found in all the experiments.

The number of ascospores which were observed to germinate in non-preheated controls never exceeded one per cent. One hundred per cent germination was not achieved in any case, the maximum found being 88.4 per cent. The results are presented in Fig. 1.

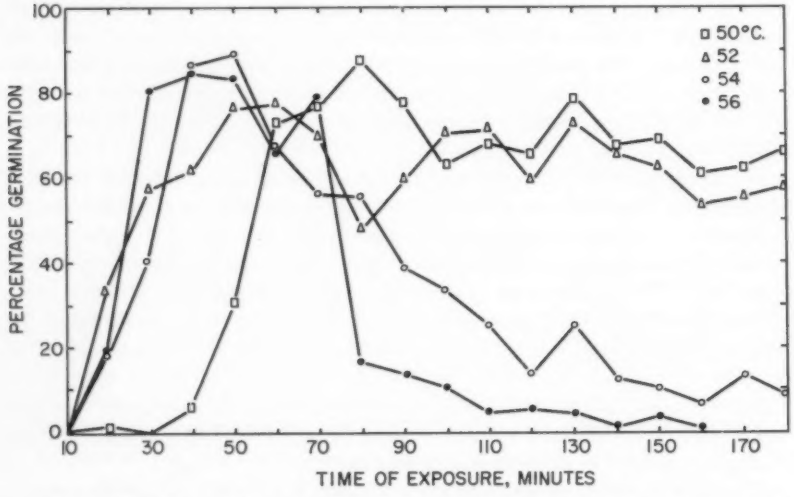

Fig. 1. The effect of time and temperature on the germination of the ascospores of the Indonesian isolate of ***N. sitophila.***

At 50° C., greatest germination was obtained after exposure for 60–70 minutes, and the percentage germination was maintained at a high level with longer exposures. At 52° C., the results were essentially similar, but

the curve is shifted to the left as the temperature is increased, indicative of a reduction in the minimal period of exposure required to induce germination. At 54° and 56° C., a high percentage germination was found after exposure for 30–70 minutes, but if the heat treatment was more prolonged, subsequent germination declined. No spores survived treatment at 56° C. for 180 minutes.

Bipolar germination of ascospores is the normal condition. The number of ascospores in which unipolar germination was observed was very small. This condition was more common following very short periods of heat treatment, but is considered insignificant.

Growth in shake cultures.—The dry weights of the Indonesian strain and known strains were determined after 8 days of growth in shake culture in the minimal medium of Beadle and Tatum (1945), with the following results:

N. sitophila 13349, 415 mg.; *N. sitophila* 13350, 355 mg.; *N. crassa* 10336, 407 mg.; *N. crassa* 10337, 406 mg.; Indonesian strain, 316 mg. While the Indonesian strain extends radially more rapidly on agar plates, when growth is judged by the dry matter production in a liquid medium, its growth is somewhat less than that of the other strains tested.

Lipase production.—The results of a comparison of the lipase producing ability of the Indonesian isolate with other strains, using peanut oil as the substrate, and based on 4 replications of the experiment, are presented in Table 2.

TABLE 2. *Lipase production by strains of* **Neurospora,** *as determined by titration of the free fatty acids produced from 1.0 ml of peanut oil with 0.02 N.NaOH.*

Strain	Titration value (ml)	Net titration value (ml)
Reagent blank	2.1	0.0
N. crassa 10336	2.75	0.65
N. crassa 10337	3.45	1.35
N. sitophila 13349	2.5	0.4
N. sitophila 13350	3.6	1.5
Indonesian isolate	4.5	2.4

It is evident that the Indonesian strain is more active in producing lipase than any of the other strains tested.

Casein digestion.—Casein digestion was observed by growing the various strains on plates of an agar medium containing 0.5 per cent powdered milk solids and observing the transparent zone around the circumference of the colonies. The casein was utilized by all strains at a rate corresponding essentially to the growth rate, and all of the plates were covered with mycelial growth so rapidly that quantitative comparisons were not possible. All of the strains were quite active in casein digestion.

DISCUSSION—The Indonesian material of *Monilia sitophila* was found to possess a perithecial stage, with asci containing eight ascospores. The morphology of the perithecium and the characteristic markings on the walls of the ascospores are typical of *Neurospora*. *N. tetrasperma* and *N. erythraea* were dismissed from consideration since their asci are 4-spored. Tai (1935) described from China a new species with 8-spored asci which he named *N. intermedia*. Cultures of this species were not available for comparison.

Conidia of the Indonesian strain are somewhat larger than those of the strains of *N. sitophila* and are much larger than those of *N. crassa*. The ascospores of the Indonesian material are comparable in size to those of *N. sitophila*. The morphology and dimensions of the perithecia of the Indonesian cultures are typical of *N. sitophila*. The crossing experiments involving the Indonesian conidial strain indicate that it crosses readily, and with high fertility, only with *N. sitophila* 9276. Since *N. sitophila* 9276 is mating type *A*, the Indonesian strain must be mating type *a*. The inconstant and low fertility noted in crosses of the Indonesian strain with *N. sitophila* 13350 or with *N. crassa* 10337 is reminiscent of earlier observations of Dodge (1932) and Moreau and Moruzi (1932), who obtained similar results in some of their mating experiments. Therefore, the evidence derived from measurements and morphology is in essential agreement with the mating experiments, and indicates that the Indonesian strains must be assigned to the species *Neurospora sitophila*.

The experiments concerned with the heat activation of ascospores of the Indonesian strain indicate that temperatures of 50–56° C. are satisfactory. A somewhat shorter minimal period of exposure to 52–56° C. than to 50° C. is required to induce a comparable percentage of spores to germinate. If heat treatment is prolonged beyond 70–80 minutes at 54° C. or at 56° C., subsequent germination is decreased. This was not the case at either of the lower temperatures. These findings indicate a somewhat complex interrelationship between time and temperature in the activation process.

The results concerned with the fat- and protein-hydrolyzing enzymes are of importance in relation to the use to which *Monilia sitophila* is put in West Java in making ontjom. It is conceivable that ontjom manufacture has resulted, over the years, in the selection of strains high in lipase activity.

The present results indicate clearly that a mold associated with ontjom and originally described as an imperfect fungus is identical with *Neurospora sitophila*. But, because ontjom manufacture is not carried out under pure culture conditions, the possibility that other species of *Neurospora*, or even totally different fungi, may also be associated with ontjom, cannot be excluded by the evidence available. The utilitarian purpose to which *N. sitophila* is put in Indonesia is probably unfamiliar to the great majority

of workers who have made use of this organism in genetic or biochemical studies.

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Chromosome numbers in nine taxa of *Potamogeton*[1]

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STERN, KINGSLEY R. (Chico State Coll., Chico, Calif.) Chromosome numbers in nine taxa of *Potamogeton*. Bull. Torrey Bot. Club **88(6)**: 411–414. 1961.—Eight new chromosome numbers and confirmation of one previously reported number in *Potamogeton* are given. A tabular listing of voucher specimens, drawings of the chromosomes, materials and methods, and a brief discussion are included.

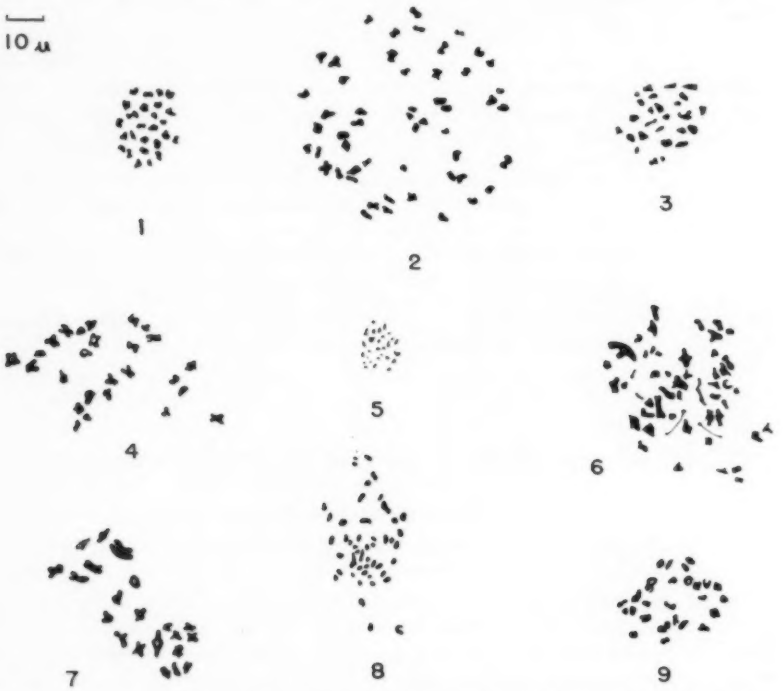
The aquatic genus *Potamogeton* comprises approximately 70 species having a world-wide distribution in temperate fresh water regions. During the course of the present study, chromosome counts were made which confirmed previous counts and which added to the list of numbers already reported for the genus.

[1] Received for publication on February 3, 1961.

This study, part of a larger project supported by the National Science Foundation under Grant G-7019, was conducted during the summer of 1960 at the Itasca Biology Session of the University of Minnesota.

[2] The author wishes gratefully to acknowledge the courtesy of Dr. Eugene C. Ogden in checking the identification of the voucher specimens and commenting to him on their anatomy and morphology.

MATERIALS AND METHODS.—Root tips were fixed in Jacobsen's Fixative (Jacobsen, 1957), subjected to a Feulgen schedule, and squashed. Microsporocytes were fixed in 1:3 propionic acid-alcohol and squashed in propionocarmine. Silicone-treated cover glasses were used with all preparations. Counts and drawings (figs. 1–9) were made immediately



FIGS. 1–9. Chromosomes of *Potamogeton* (drawn with the aid of camera lucida). All × ca. 600.—FIG. 1. *P. richardsonii*. Metaphase I. $n = 26$.—FIG. 2. *P. richardsonii* (?) (Putative octoploid). Metaphase I. $n = 52$.—FIG. 3. *P. robbinsii* Metaphase I. $n = 26$.—FIG. 4. *P. gramineus*. Diakinesis. $n = 26$.—FIG. 5. *P. foliosus*. Somatic prometaphase. $2n = 28$.—FIG. 6. *P. illinoensis*. Metaphase I. $n = 52$.—FIG. 7. *P. natans*. Diakinesis. $n = 21$.—FIG. 8. Putative hybrid (parentage uncertain). Metaphase I. $n =$ ca. 52.—FIG. 9. *P. amplifolius*. Diakinesis. $n = 26$.

after squashing, and the slides subsequently were made permanent. The slides have been retained in the author's permanent collection. Each chromosome number determination is based on counts obtained from 10 to 25 microsporocytes or, in one case, 4 root meristem cells. Voucher specimens have been deposited in the herbarium of the University of Minnesota, Minneapolis.

RESULTS AND DISCUSSION.—Since 1939, when Palmgren made the first intensive cytological investigation of the genus, chromosome numbers ranging from $2n = 26$ to $2n = 78$ have been reported for about half the species (see Darlington and Wylie, 1956; Cave *et al.*, 1958). Most reports indicate a base of $x = 13$ or 14. Some exceptions, noted by Ogden (1943), indicated uncertainty on the part of some authors about the numbers they were reporting.

Four of the nine taxa reported here (table 1) are tetraploids, and eight of the nine taxa confirm the previously reported base numbers of $x = 13$ or 14 (figs. 1–6, 8–9).

TABLE 1. *Chromosome numbers in* **Potamogeton** *L., Subgenus* **Eupotamogeton** *Raunk. All localities in Itasca State Park, Minnesota.*

Collection data	Chromosome number	Fig. no.
P. amplifolius Tuckerm.		
Squaw Lake, Clearwater County, *K. R. Stern 633*	n = 26	9
P. foliosus Raf.		
Squaw Lake, Clearwater County, *K. R. Stern 634*	2n = 28	5
P. gramineus L.		
Squaw Lake, Clearwater County, *K. R. Stern 639*	n = 26[3]	4
P. illinoensis Morong		
Lake Itasca, Clearwater County, *K. R. Stern 642*	n = 52	6
P. natans L.		
Pond, 0.3 mi. w of e entrance to Park, Hubbard County, *K. R. Stern 618*	n = 21	7
P. richardsonii (Benn.) Rydb.		
Lake Itasca, Clearwater County, *K. R. Stern 605*	n = 26	1
P. robbinsii Oakes		
Squaw Lake, Clearwater County, *K. R. Stern 638*	n = 26	3
Putative octoploid form of *P. richardsonii* (?—see text)		
Small stream flowing n from ne end of Squaw Lake, Clearwater County, *K. R. Stern 635*	n = 52	2
Putative hybrid, parentage uncertain (see text)		
Squaw Lake, Clearwater County, *K. R. Stern 637*	n = ca. 52	8

[3] Confirmation of previous report (Palmgren, 1939).

One tetraploid species, *P. richardsonii*, possibly also occurs in an octoploid form, or appears at least to be involved in the parentage of an octoploid hybrid. The anatomy of the stem of Collection No. 635 (table 1, fig. 2), on which an octoploid chromosome number is based, is typical for *P. richardsonii*. Possible clues to another species being involved in the parentage lie in the slightly atypical leaf bases, which are not fully clasping, and in the upper leaves of some of the specimens being slightly coriaceous. This latter characteristic conceivably could indicate a parent with floating leaves.

Collection No. 637 (table 1, fig. 8), also octoploid in nature, appears on the basis of morphology and anatomy to be a hybrid, with *P. richardsonii* a probable parent. The anatomy of the stem indicates the other parent is

most likely to be one having cortical bundles, possibly *P. illinoensis* or *P. gramineus*.

Potamogeton illinoensis has a haploid number of $n = 52$ (fig. 6). Approximately 30 counts were made of the meiotic chromosomes of two morphologically distinct forms of this species. No apparent cytological correlation with the variable external morphology was found, the chromosomes being reasonably constant in number and in their distinctive morphology in the microsporocytes examined.

A haploid number of $n = 26$ was reported for *P. natans* by Palmgren (1939). The haploid number of $n = 21$ reported here for this species is, perhaps, a little surprising. However, two Japanese species, *P. apertus* and *P. kamogawensis* are reported to have similar complements (Harada, 1942). In this notoriously variable genus, it would seem quite possible that the chromosomal complements might vary in a number of the taxa. Such variations have been noted within natural populations of other genera, e.g., *Clarkia* (Lewis, 1951). However, in *Potamogeton* there is a paucity of evidence at present to substantiate this hypothesis.

These and previously reported chromosome numbers indicate that a thorough cytotaxonomic investigation of this genus should yield interesting results, and would be a valuable adjunct to the previous extensive morphological and anatomical studies of Ogden (1943), Fernald (1932), St. John (1916), and others.

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BULLETIN OF THE TORREY BOTANICAL CLUB

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TORREYA

Paul Peter Bedesem, Jr.

Botany lost a scholar as well as an able and willing worker in the death of Dr. Paul P. Bedesem, Jr., on February 10, 1961. Born in Philadelphia, Pa., Dec. 22, 1927, he graduated from Temple University as a major in biological sciences in 1950. His record at Temple won him a teaching assistantship at Columbia where he studied with Professor E. B. Matzke and others. The Master of Arts degree in botany was achieved in 1952. A year later he married Helen Winsor Rounds. In 1954, while the doctorate work was in progress, he was appointed instructor in biologocal sciences at San Francisco State College. In 1957 the Ph.D. in botany at Columbia University was completed and with it came a promotion to assistant professor at S. F. S. C. The doctorate dissertion was published: "Histogenetic Effects of 2, 3, 5 Triiodobenzoic Acid on the Shoot Apices and Leaf Primordia of Tomato." Bull. Torrey Bot. Club **85**: 434–472. 1958.

Dr. Bedesem's research interest continued in the field of experimental morphogenesis

PAUL PETER BEDESEM, Jr.
December 22, 1927–February 10, 1961

and in addition to his teaching obligations at S. F. S. C. he began investigating the form and structure of two flat-stemmed genera, *Homalocladium* and *Carmichaelia*. A preliminary report on this research was made before the Botanical Society of America at the Oklahoma State University meetings of American Institute of Biological Sciences in 1960 under the title, "Apical Structure of Certain Isobilateral Stems."

It is not easy to document a man's teaching excellence. Dr. Bedesem joined the Department of Biological Sciences at Douglass College, Rutgers, The State University of New Jersey July 1, 1960, with excellent references from Columbia University and the San Francisco State College. He was assigned the course in general botany and that in comparative morphology. In each course the students and the instructor worked hard and successfully. The students and teaching assistants enjoyed working with him. He was readily accepted by and contributed to the University wide Faculty of Botany. He looked forward eagerly to membership in the Graduate Faculty and the supervision of graduate work in his field. He participated in activities of the Torrey Botanical Club. Professional affiliations other than those above included The American Association for the Advancement of Science, California Botanical Society, and the National Association of Biology Teachers.—JOHN A. SMALL, Rutgers.

CYCLONEXIS ANNULARIS IN NEW JERSEY

E. T. MOUL

The original discovery and description of *Cyclonexis annularis* Stokes (Chrysomonadales) was recorded in 1886 from collections made in New Jersey (Stokes, 1886). Since that time there have been a number of widely scattered records of its occurrence in this country and in Europe. There has been little recorded concerning its particular habitat.

Tiffany (1934) recorded it from a hatchery at the west end of Lake Erie where it was quite abundant on July 1, 1933, but was not seen again. E. W. Thompson (Whelden, 1939) collected it from a small pool formed by an obstruction of a small brook near Andover, Massachusetts, in May of 1938. R. H. Thompson (1948) reported it from a small bog in Maryland. L. A. Whitford (1960) in a recent paper on the Ecology of Algae reported finding it in North Carolina during the winter of 1958–59. The species has been reported from England by Grove (1920) and by Pascher (1913) from Germany.

As this species was first recorded from New Jersey, it gives me great satisfaction to be able to add records for the state. Since September, 1948 a series of small bog ponds and flooded sand pits in Middlesex County have been kept under observation and collections were made and preserved for future study. Preliminary examinations were made of all collections in order to note the presence of those species that do not preserve well. *Cyclonexis annularis* was first found in collections made on the 19th of January, 1949 and occurred in collections made frequently until the 6th of April. Many collections were made when the pools were covered with ice. Subsequent collections have been made in the same locality from 1951 to 1954.

The species has also appeared in collections made from a water-filled, abandoned sand pit at Dallenbach's in Middlesex County. There is one collection from a swamp pool near Pine Lake in Sussex County, New Jersey. All collections of this species were made between January and April.

There are a number of environmental factors common to the localities from which this species has been collected. All of the pools are small, contain sphagnum moss and are surrounded by dense growth of trees and shrubs that provide some shading even in winter. The range of pH is from 4.5 to 7, with most records between 4.5 and 6. The temperature of the waters from which collections were made ranged from 1.5°C to 19°C, the majority of collections, however, being from waters at temperatures below 10°C.

When a pipette was used to collect the water close to and around sphagnum plants, greater numbers of colonies were secured. Whelden (1939) used this method in collecting the organisms from among maple leaves at the bottom of the pond in Massachusetts. Squeezing masses of sphagnum and Fontinalis moss or bottom material was another way in which the organism was collected.

The number of cells in a colony ranged from 5 to 20, the average number of cells was 14. All the cells of a colony are the same size, but on one occasion three large cells were observed in the circle of the colony, in such a position as to form a triangle. One colony measured 37.5 microns in diameter. The colony rotates clockwise rather slowly and moves with the flagella end forward. The longer flagellum of each cell extends outward from the center, while the shorter one extends inward. These colonies tend to break apart after a few minutes of observation, and then the individual cells themselves burst. Only on one occasion did I see a cell break from the colony and the circle come together again and continue swimming. This destruction of the colonies has also been reported by Whelden (1939). Attempts to keep the colonies alive overnight by placing the collection in a lighted refrigerator have failed. Preservation of the specimens has also failed. Culturing the organism should be a challenge to someone's ingenuity. This method of study would solve the suggestion made by Thompson (1948) that *Chrysostephanosphaera globulifera* Scherffel is the palmella stage of *Cyclonexis annularis*.

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Field Trip Reports

April 9. Pelham Bay Park, Bronx, N. Y. The group was large, but fortunately there were two leaders in charge, Eleanor Yarrow and the undersigned. While the spring-beauty was already in bloom, many of the trees and shrubs were still in hibernal bud—good for the principal objective of the field trip, the study of the spring aspects of winter botany. We carefully examined the plane-tree's crenulate leaf-scar, which is said to encircle the bud. Even in its fullest development, however, it does not entirely encircle the casque-like bud, but falls short of a complete ring. The red and silver maples were both in bud and in bloom, conveniently near to each other for comparison. Although the two species are closely related and are placed in the same group by most botanists, their flowers are strikingly different in appearance. The flower of the red maple has free sepals, red petals, and a glabrous ovary; in the silver maple the sepals are united into a turbinate or campanulate tube, petals are lacking, and the ovary is white-woolly. Generally the flower is regarded as the most important criterion for classification; was it the arbitrary adherence to this precept that induced a botanist to propose separate genera (*Rufacer* and *Argentacer*) for the two species? The American elm was also in bloom. Its simplified perianth somewhat resembles that of the silver maple. The margins of the ovary were puberulous, anticipating the characteristic cilia that would later develope on the samara. On route to Orchard Beach we saw the grand old stand of white poplars, widely skirted with bristling thickets of countless root-suckers. Did our little silver forest grow from a single tree planted many years ago?

Does the whole burgeoning forest consist of but one or two clones? Only staminate catkins were seen. Co-leader, Joseph Monachino

May 14. Green Engineering Camp, Ringwood, New Jersey. This trip was confined to the Camp grounds, which are spacious, diversified and interesting. The morning was devoted to a bird walk under the guidance of Benjamin Gilbert. Mrs. Dowden has through the years studied intensively the flowers of an area of the Camp and has prepared a pictorial book on them, which is expected to be published soon. The fringe-petalled *Mitella diphylla* grows here and also the maidenhair fern and other native woodsy species. We stopped longer, however, to admire a weed that had spread abundantly throughout the lawn, *Veronica serpyllifolia*, the flower with a corolla of the faintest tinge of blue (light yellow at the base of the short tube) and two purplish-blue anthers on the tips of elavate white filaments. Someone shouted that he had found the two flower-size varieties of *Glecoma hederacea* and there, indeed, growing side by side one had a flower over twice as large as the other. However, the writer demonstrated that flower-size, at least in this instance, was correlated with the sexual phase, the hermaphrodite plant having much the larger corolla. Bill Rissanen pointed out the scaly liverwort *Frullania eboracensis* covering the bark of a tree; the common fern-moss, *Thuidium delicatulum*, beautiful to behold on the trail and even more beautiful when seen under the microscope (see the cellular filamentose paraphyllia, especially by transmitted light!); *Ditrichum pallidum* (identified by Mulford Martin) with very pale yellow setae; the slime-mold *Lycogala epidendrum*, globose, grey-brown and minutely orange-warted. We saw a handsome *Pluteus cervinus* that had cast its spores on a spider-web. The spore print of this species is called "rosy" by a mycologist, but it is hard for your reporter to see true rose in it; it is perhaps nearest "cinnamon-buff" in Ridgway's Color Standards. In swamp muck, associated with Juncus and Carex, the dull brown cups emersed from the shallow water, grew a *Sclerotinia* which was collected by Dr. George M. Luedemann. The collection was transmitted to Dr. Clark T. Rogerson at The New York Botanical Garden, who wrote "The *Sclerotinia* from Green Engineering Camp proves to be *Sclerotinia longisclerotialis* Whetzel. The long black, striate sclerotia, up to 7 cm in length which develop in the culms of *Carex* spp. distinguish the species from others on *Carex* as well as one on *Juncus*. Buehwald (1947) would call the species *Myriosclerotinia longisclerotialis* (Whetzel) Buehwald. Whetzel (1929) described the species from central New York and reported it from Maine also. The only other record that I know of is Manitoba. This may be a new record for New Jersey. I will deposit part of the collection in New York and send part to Kerf." Leaders Ophelia Dowden and Dr. Ellis Blade. Reported by Joseph Monachino.

June 24. Van Cortlandt Park, Bronx, N. Y. The trip was primarily for the study of insects under the leadership of Dr. John Pallister, Research Associate in Coleoptera, Department of Entomology, The American Museum of Natural History, but botany was also represented both in its relationship to insects and for its own interest. Some plant galls were cut open and the larvae within examined. The fly larvae were seen to be wrigglers, worm-like in appearance and movement, clinging by means of suckers at their hind ends; the lepidopterous larvae were shown to have thoracic legs and to move with an undulating motion. We observed the larvae of the irridescent-golden tortoise beetle on the field bindweed; they appeared to fan themselves with the remains of cast-off skins held on tail-like forks at the ends of their bodies. With each moult the forks of the last stage is telescoped out upon the new, and the number of cast skins can be counted. Mulford Martin of The New York Botanical Garden was on hand to identify the mosses. He delighted us with the gemmae cups of *Tetraphis pellucida*, tiny leafy rosettes nesting green minute lenticular bodies. There was some controversy regarding a cat-tail that had thick spikes and broad leaves as in *Typha latifolia* but the staminate and pistillate portions of the spike separated, not contiguous. The spatulate stigmas and the tetrad pollen (checked by J. Monachino at The New York Botanical Garden) proved it to be really *T. latifolia*, the so-called forma *ambigua*. The typical narrow-leaved cat-tail was also present in the Van Cortlandt swamp, and also a thick-spiked (2 cm. thick) broad-leaved

(12mm. broad) kind without question of *T. angustifolia* affinity, perhaps the taxon named *T. glauca*. Attendance 12. Leader, John Pallister. Reported by Eleanor Yarrow.

July 2. Pelham Bay Park, Bronx, New York. In a sterile caked-mud plot of ground the leader collected *Puccinellia distans*, recently adventive in the Park. Also probably introduced during the recent thruway construction work was birdfoot-trefoil,*Lotus corniculatus*, and this bright-yellow flowered weed inspired a discussion on the proper interpretation of its leaf morphology. The foliage has been described as "leaves 5-foliolate, stipules none" and "stipules nearly as large as the lower leaflets, so that the leaf appears to have 5 leaflets". But very minute gland-like stipules are present, analogous to those in the Western American species of *Lotus* described as having "stipules reduced to glands"; the basal pair of leaflets have normal petiole-cushions like those in the three terminal leaflets. Our attention then turned to the pineapple-scented pineapple-weed, the rayless and pappusless lowly *Matricaria matricarioides*, a prodigious weed from Western America, that is now reported from such far corners of the earth as New Zealand. It has become established in all five boroughs of New York City, it would seem within the memory of your Field Chairman. Not far off we saw the bright-red fruited (the achenes as well as the receptacle are red)! Indian strawberry, *Duchesnea indica*. Shortly after we turned off for Solidago Odora Island in the East Chester marsh, immediately west of the old abandoned Bartow Station. There Eleanor Yarrow, with mighty heave, plucked a plant of the vestal-white flowered *Ceanothus americanus* and, scratching the surface of the root, revealed the blood-red color, whence the name redroot; also unearthing *Collinsonia canadensis* she showed the stone-hard root, whence the name stoneroot. *Asclepias purpurascens* was in bloom. Why are the flowers of this species called purple? They are more magenta; F. Schuyler Mathews says magenta-crimson and adds "but they are never purple". *Panicum clandestinum* was there, and also two other broad-leaved panicums which simulated each other, *P. latifolium* and *P. boscii*, the last with barbate nodes and larger spikelets. *P. latifolium* sometimes had spikelets only 3 mm long, but J. R. Swallen verified the determination (his specimen measured 3.4 mm). The carrion-flower was the variety characterized by leaves pulverulent and bright green beneath (the fruit was not found), *Smilax herbacea* var. *pulverulenta;* we saw several examples of that puzzling phase with short erect stems terminated by a false whorl of leaves without tendrils. *Desmodium cuspidatum*, not known by the writer from any place else in the City, was not yet in flower, yet the stipules had shed. Another tick-trefoil in leaf only was clearly *D. paniculatum*, but a broader-leaved one, probably belonging to the *P. dillenii* complex, should be studied when in fruit. The species of bush-clovers were *Lespedeza hirta*, *L. intermedia* and *L. virginica*. So to contribute to a florula of the island other species observed will be herewith listed: *Osmunda regalis* var. *spectabilis*, *Dryopteris noveboracensis*, *Pteridium aquilinum* var. *latiusculum*, *Calamagrostis canadensis*, *Danthonia compressa*, *Festuca rubra*, *Glyceria striata*, *Panicum dichotomum*, *P. lanuginosum* var. *fasciculatum*, *Carex cephalophora*, *C. laxiculmis*, *C. rosea* (broadest blade up to 2.5 mm wide; not distinguished from *C. convoluta*), *Juncus effusus* var. *solutus*, *Hemerocallis fulva*, *Polygonatum biflorum*, *Smilacina racemosa*, *Dioscorea villosa*, *Castanea dentata* (sprouts), *Cimicifuga racemosa* (sparse), *Heuchera americana* (sparse, near the bugbane), *Geum canadense* (the common avens in the City, but what variety or forma?), *Baptisia tinctoria* var. *crebra*, *Vitis aestivalis* var. *argentifolia*, *Hypericum perforatum*, *H. punctatum*, *Lysimachia ciliata*, *L. quadrifolia*, *Aralia nudicaulis* (sterile), *Cryptotaenia canadensis*, *Sanicula canadensis*, *Nepeta cataria*, *Gerardia flava* (common; last year's dark capsules conspicuous), *Gerardia virginica* (rare; flower-buds just beginning), *Scrophularia lanceolata*, *Triosteum perfoliatum*, *Eupatorium sessilifolium* (flowers in young bud), *Helianthus divaricatus* (flower-heads beginning to form), *Hieracium venosum*, *Rudbeckia serotina*, *Sericocarpus asteroides* (if considered a species of Aster, the earliest flowering in our area). Attendance 9. Leader, Joseph Monachino.

July 23. Staten Island Arboretum. The campus of Wagner College, situated in a natural Staten Island woodland, has quite a lot of native flora left. This is augmented by numerous plantings of cultivated trees and shrubs as well as several experimental

rose gardens, which are supplied by a rose nursery. The native woodlands are composed of large tulip-trees, American beech, red, black, scarlet, and white oaks as well as a few sweet gum. The few flowering dogwoods are not in very good condition. Several small red buckeye *(Aesculus Pavia)* are planted near one of the buildings. In the more formal plantings, near the main buildings, are a number of fine specimens of *Albizzia julibriscense* and these were at the height of their bloom. Attendance 12. Leader, Mathilde P. Weingartner.

July 30. Canarsie, Brooklyn, New York. The fact that our knowledge of the distribution of the local flora is still far from complete after more than 200 years of study is well illustrated by the fact that the fifteen people who visited the Canarsie section of Brooklyn on July 30 observed 93 species of plants, 11 of which have not previously been reported from Kings County. The writer has yet to take a field trip in this area without being able to add at least one plant to the county list. And Kings County is by no means unique in this respect. Listed below are the 19 plants encountered on the July 30 field trip which have not been included in earlier reports. An asterisk preceding the name indicates a new record for the county; the rest of the species listed are on the New York State Museum check list of Kings County flora.

Pteridium aquilinum latiusculum
**Humulus japonicus*
Polygonum caespitosum longisetum
**Gleditsia triacanthos*
**Acer negundo*
**Phlox paniculata*
**Verbena urticifolia*
Mentha arvensis
**Mentha spicata*
Diodia teres
**Sambucus canadensis*
**Erigeron annuus*
**Agrostis gigantea*
Panicum clandestinum
Phleum pratense
Setaria viridis
**Carex vulpinoidea*
Rhynchospora glomerata
**Scirpus cyperinus*

On practically every field trip in late summer the question as to whether a certain plant is a wild-lettuce or a sow-thistle usually arises, for both *Lactuca* and *Sonchus* are relatively common. Actually, in our area it is not difficult to separate the two genera when they are in flower. In the Northeast, at least, flowers of *Sonchus* are yellow; *Lactuca* flowers may be yellow, bluish, or white (cream). The yellow *Lectuca*, however, has a filiform beak separating the body of the achene from the pappus. Yellow-flowered plants with beaked achenes are therefore *Lactuca;* if no beak is present, the plant is *Sonchus.* The only fly in the ointment is a yellow-flowered form of *L. biennis.* The pappus of *Sonchus* is always very white; that of *L. biennis,* on the other hand, is sordid to olivaceous or tawny. Leader, Karl L. Brooks.

August 5. Franklin Lakes, N. J. This trip was enthusiastically attended, as usual. Twenty species of seed plants were conspicuous or otherwise interesting enough to record: three species of smartweed, wild yam, starry campion, rattlesnake plantain (several in bloom), early everlasting, sicklepod, seedbox *(Ludwigia alternifolia),* clearweed, climbing fumitory, blue-curls, common thistle, star thistle, bergamot, ironweed, Joe-Pye-weed, jewelweed, red baneberry (with berries), and red elder (with berries). Half as many ferns were recorded: lady-, New York, marsh, royal, interrupted, cinnamon, spinulose wood-, sensitive, grape (leathery), and walking. Many mosses and a great variety of mushrooms proved a delight to all both for identification and for photographs. Attendance 17. Leader, Lucy Kemp.

August 6. Silver Lake Park and Goodhue Woods, Staten Island, N. Y. Many of the trees and shrubs seen on this field trip were coming into fruit. Blackberries were ripe, including *Rubus laciniata,* Highbush cranberry (*Viburnum opulum*) showed red fruits while the horsechestnut and London plane tree showed round seed balls. On *Solanum Dulcamara* one could observe the flowers as well as the fruits in all stages of ripening. The trip terminated at the home of the leader, where a picnic supper was held. Attendance 15. Leader, Mathilde Weingartner.

Book Reviews

Marine Algae of the Eastern Tropical and Subtropical Coasts of the Americas. By W. R. Taylor. The University of Michigan Press, Ann Arbor. ix + [2] + 870 pp. including 80 pls. [August 26] 1960. $19.50.

Among warm-water seas, the Caribbean is second only to the Mediterranean as regards the length of time and extent that its marine flora has been studied. Many genera and species, some with wide distribution in tropical waters, are based upon material from this area. Professor Taylor has rendered phycology an outstanding service by bringing together in a single volume knowledge of the algae of this historically and floristically important part of the world. Nothing comparable exists for any other large area in the tropics. The area covered extends from Bermuda and North Carolina to southern Brazil, with a few extensions of range into Uruguay. Regions within this area for which major works or lists of species existed are Bermuda, North Carolina, Florida, the Bahamas, Cuba, Jamaica, Puerto Rico and certain other Antillean islands, and Brazil.

Although previous accounts facilitated Taylor's task, they also immensely complicated it. Our predecessors did not have the opportunities available today (and in many instances lacked the inclination) to visit other institutions or to borrow material, and consequently they usually described specimens as new species or referred them to old species on the basis of a comparison of descriptions rather than of materials. Taylor was confronted with a vast number of published records which he had to evaluate in order to bring as much order as possible into the existing confusion. Many old records, including species originally described from the area, remain to be evaluated. Most of these are listed at the end of the genus in question; others are listed as doubtful synonyms under accepted species. Some recorded species, as the author suspects, have been overlooked by him, as for example, *Phyllactidium marinum* Grunow, reported from Guadeloupe, and *Calloseris halliae* J. Agardh, a monotypic genus of Delesseriaceae based upon material from Florida. These unresolved records will plague algal geographers, but as the author points out, this is a pioneer flora. To have pursued all these problems would have taken many additional years of work. One of the tasks of future students of the Caribbean flora will be to locate and study the material upon which these records are based. Some of the specimens undoubtedly have been lost, but voucher material for most of the records probably can be found. In a few instances, as in the case of *Derbesia fastigiata* and *Ectocarpus zonariae*, both of which had been erected by Taylor but were relegated to "uncertain records" in the present work, it would seem that he was in a better position than anyone else will ever be to settle their status.

In the introduction the author gives a brief discussion of the geographic distribution of the Caribbean algae, among other topics, and an outstanding account of algal habitats in the area, illustrated with 14 excellent photographs. Guided by his long experience with algal taxonomy, he refrained from making elaborate comparisons with the floras of other regions. I share his view that our knowledge of the floras of most parts of the world and of the exact identity of many species is still so inadequate that it is meaningless to make such comparisons.

The bulk of the volume is devoted to a description of the taxa. Excellent illustrations are given of the habit, and where necessary, of the structural details of a large number of species. Orders, families, genera, species, and varieties are characterized, and keys are furnished to taxa below the rank of order. The localities in the area whence each species has been reported are listed and the references supporting this distribution are given. These references frequently, but not always, include the one containing the original description of the species if it is based upon Caribbean material.

In addition to the author, the year of publication of each genus is given. It is not clear, however, why this was done because almost invariably these references are not included in the bibliography. In a few instances the wrong author, and in a fairly large number of cases the wrong date, is given.

The sheer magnitude of this work makes errors and oversights excusable, and yet it seems a function of a reviewer to bring attention to at least some of them.

The nomenclature in general is up-to-date. The following are a few oversights. The combination *Pringsheimiella udoteae* had previously been made by Schmidt and Petrak; the type of *Ulva lactuca* var. *latissima* is a species of *Laminaria;* the correct name of *Caulerpa racemosa* var. *chemnitzia* (Esper) Weber-van Bosse is *C. racemosa* var. *turbinata* (J. Agardh) Eubank; the new combinations *Caulerpa mexicana* f. *pectinata* (Kützing) Taylor and *C. serrulata* f. *pectinata* (Kützing) Taylor both have *Caulerpa pectinata* Kützing as basionym, which is not permissible. The new variety *caroliniana* of *Rhodymenia pseudopalmata* was not illustrated and hence is invalid; *Taenioma macrourum* Thuret should be called *T. nanum* (Kützing) Papenfuss; *Cryptopleura lacerata* (Gmelin) Kützing should be known as *C. ramosa* (Hudson) Kylin ex Newton.

The classification of algae admittedly is in a state of flux and differences of opinion exist as to the family position of many genera and the ordinal position of some families. Taylor's classification in some groups departs from that of other recent authors. In some instances these departures probably are oversights, in other cases they may convey his personal convictions. However, he has not presented arguments in support of his classifications and it is not possible, therefore, to evaluate them.

In the green algae, *Diplochaete* is placed in the family Chaetopeltidaceae whereas Thivy has referred it to the Chaetosphaeridiaceae. In any event, the Chaetopeltidaceae should not be placed in the Ulotrichales, as Taylor has done, because *Chaetopeltis*, the type of this family, has been shown by Korshikov to be a member of the Tetrasporaceae.

The Dasycladaceae are assigned to the Siphonocladales. The members of this family possess a number of features which sharply distinguish them from all other green algae and there seems to be no justification for not accepting the order Dasycladales. Among the Dasycladaceae the author recognizes *Chalmasia* and *Acicularia*. In overall morphology these two genera are very similar to *Acetabularia*. In both *Chalmasia* and *Acicularia* the cysts are calcified; they are free from one another in *Chalmasia* but cemented to one another in *Acicularia*. In *Acetabularia* the cysts are uncalcified (Taylor in error described them as calcified). The presence or absence of calcium carbonate in the cysts and the degree of calcification are hardly characters of sufficient magnitude to warrant the splitting of *Acetabularia* into three genera, as Egerod has pointed out. The reproductive organs of members of the Dasydadales are gametangial in nature and it is not correct to refer to them as sporangia, as Taylor has done.

The family Valoniaceae (Siphonocladales) as treated by Taylor includes an extremely heterogeneous assemblage of algae. Of the genera occurring in the Caribbean, only *Valonia, Valoniopsis* and *Dictyosphaeria* appear to be referable to this family. *Halicystis* is a stage in the life history of *Derbesia* (Siphonales, Derbesiaceae). *Microdictyon, Cystodictyon,* and *Anadyomene* are usually placed in the Anadyomenaceae, a family which the reviewer in 1955 removed to the Cladophorales. *Chamaedoris, Petrosiphon, Siphonocladus, Cladophoropsis* and *Ernodesmis* are usually placed in the Siphonocladaceae, and *Boodlea* and *Struvea* are usually placed in the Boodleaceae.

Mangenot has produced evidence confirming the opinion of Blackman and Tansley that the family Phyllosiphonaceae (or at least *Phyllosiphon*) belongs in the Xanthophyceae instead of in the Chlorophyceae (Siphonales).

Haplospora vidovichii is usually considered to be a species of *Acinetospora* and Kornmann has produced convincing evidence necessitating the removal of *Acinetospora* from the Tilopteridales to the Ectocarpales. It would seem, therefore, that the Tilopteridales are not represented in the Caribbean flora.

Zonaria is described as lacking paraphyses in the sporangial sori and *Stypopodium* as having paraphyses. Actually the situation is the other way around.

In the Nemalionales, *Gloiophlaea* is credited with two species, both of which are described as possessing a cortex composed in part of utricles. It has been found by Levring, however, that the type species of *Gloiophlaea* lacks utricles. *Gloiophlaea halliae* Setchell and *G. caribaea* Taylor are therefore probably not representative of *Gloiophlaea*.

The precedent set by Kjellman in 1900 of recognizing the gametophytic and tetra-

sporangial generations of *Galaxaura* as separate species is unfortunately followed in this work, but with the gratifying departure that in some instances suggestions are made as to which pairs of "species" may be stages in the same life history. As in other red algae, the gametophytic and tetrasporangial stages of the species of *Galaxaura* resemble each other and it is to be hoped that as these plants become better known in the field, the practice of assigning them to different species can be abandoned.

A new family is erected for *Wurdemannia*. The systemtic position of this genus has been uncertain for a long time and the establishment of a new family to accommodate it is probably justified. Neither *Wurdemannia*, which possesses zonately divided tetrasporangia, nor *Gelidiopsis*, however, should be referred to the Gelidiales. *Gelidiopsis* has been shown to belong to the Gracilariaceae (Gigartinales). In the absence of cystocarps, the ordinal position of *Wurdemannia* remains uncertain but it probably belongs either to the Gigartinales or the Cryptonemiales, both of which possess genera with zonately divided sporangia.

Phycology has been greatly furthered by this volume. It will be used, with gratitude to the author, by a large number of the biologists concerned with the Caribbean biota and will serve as a reference work wherever marine algae are studied. There are still many problems relating to the taxonomy of the Caribbean algae that await solution. These have not been concealed in this book, as sometimes is the case in systematic works. It is to be hoped that students of the algae will avail themselve of the opportunities that exist today for travel to and work at the many marine laboratories that in recent times have been established in the Caribbean. Armed with Professor Taylor's guide to the flora, it should be a joy to work in the area.—GEORGE F. PAPENFUSS, Department of Botany, University of California, Berkeley.

Morphology of the Angiosperms. By Arthur J. Eames. xiii + 518 pages. McGraw-Hill, New York, 1961. $13.50.

In "Morphology of the Angiosperms" Professor Eames has produced a distinguished volume which reflects the mature scholarship of a lifetime of study and research. His familiarity with angiosperms has made possible a comparative study. A lesser botanist might have been overwhelmed by the enormous literature of angiosperms, this, however, was avoided by placing emphasis upon evolutionary modifications and their phyletic implications in the selection of material. The book is divided into four parts: the plant body (66 pages); structures and processes concerned with reproduction: these include inflorescence, flower, androecium, stamen, pollen, pollination, male gametophyte, gynoecium, carpel, ovule, archesporium, embryosac, endosperm, fertilization, embryo, seed, and fruit (316 pages); morphology of selected families (87 pages); and phylogeny of the angiosperms (8 pages).

Botanists have impatiently awaited the completion of "Morphology of the Angiosperms" and now that it has appeared will be both disappointed and delighted; disappointed in that it is not an inclusive compendium, for much material important to specialists has been eliminated, and delighted in that Professor Eames has prepared an eminently usable textbook for graduate level classes. Students who have mastered this text will be aware of the areas where research can be attempted in angiosperms most profitably. Structure having phyletic implications, especially that yielding a picture of primitive angiosperms, is fully described and illustrated; it is then discussed and interpreted. Consequently the student is not left with conflicting interpretations and theories but rather with Professor Eames' clearly reasoned conclusions. Admittedly this method has advantages and disadvantages; these need not be discussed here for they are familiar subjects of debate in academic circles. The most serious shortcoming of the book is the complete elimination of reference to the admirably selected list of literature citations at the close of each chapter. This has shortened the text somewhat but at the expense of the students' time in discovering the source for much of the material described. True, the large number of illustrations with citation to their source helps tie the text to the literature.

Chapter 6, "The Gynoecium", may be taken as illustrating the breadth and scope of treatment. Here our knowledge of the carpel is detailed under the following headings: form and closure of the carpel, modification of the follicular carpel, the solid carpel, the stigma and transmitting tissue, placentation, morphological nature of the carpel, ontogeny of the carpel, anatomy of the carpel, syncarpy, and the inferior ovary. This is excellent reporting but Eames goes further, for example in discussing the closure of the carpel, he warns the student that while the closed carpel may be cited as the distinguishing characteristic of angiosperms yet it is not an ancient angiosperm characteristic but is still in the process of being established. Closure has occurred in many ways and independently in many lines, and while conduplicate closure is undoubtedly primitive, vascular anatomy suggests that involute closure has not been derived from conduplicate.

Chapter 4, "The Androecium", Chapter 6, "The Gynoecium", and Chapter 11, "Notes on the Morphology of Selected Families", are not only the outstanding chapters of the book but are not equalled elsewhere in the literature of angiosperms. The foliar nature of the primitive stamen and carpel is strongly endorsed to the extent that: "the vascular structure of stamens, as a whole, gives no support to the hypothesis of telome structure in the stamen;---" and "---, none of the twentieth century concepts of the nature of the carpel can displace the classical view that the carpel is a fertile lateral appendage of a determinate stem tip." In Chapter 11 no attempt is made to suggest a "family tree" but instead to illustrate the sum total of primitive and advanced characteristics in taxa commonly regarded as primitive viz., the Ranales, Dilleniales, Piperales, Verticillatae, Helobiales, Liliales and Palmae. This treatment has the advantage of placing emphasis on the presumed origin of angiospermy but fails to focus attention on either the extent of specialization or the retention of primitive features in highly evolved angiosperm taxa.

The essay on phylogeny of the angiosperms (Chapter 12) will be very useful to students for it succinctly brings together the principal theories on the origin of the angiosperms—Stachyospory-Phyllospory theory, Isoetes-monocotyledon theory, Coniferales-Amentiferae theory, gymnosperm-Gnetales-angiosperm theory, Anthostrobilus theory, Caytonialian theory and Pteridosperm theory—, all are rejected. Professor Eames' considered opinion is best summarized in his own words: "Ancestry for the angiosperms should probably be sought far back in the eusporangiate line, as far as the Permian, when beetles are first known. Seed bearing is perhaps not an essential character in the ancestral forms."

The publishers are to be congratulated: the format is dignified as becomes an advanced textbook, the illustrations do not overshadow the text but for the most part are line drawings fully adequate for their purpose, there are few typographical errors, and the index (40 pages) is gratifyingly complete.

"Morphology of the Angiosperms" will be used widely as a textbook at the graduate level. Certainly it merits such recognition.—MARION A. JOHNSON, Department of Botany, Rutgers University

Growth, Development, and Pattern. By N. J. Berrill. 555 pp. 252 figs. W. H. Freeman. 1961. $10.00.

Although modern studies and speculations concerning viruses and the origin of life tend to obliterate the distinction between the animate and inanimate, morphogenesis still points to fundamental differences. How plants and animals, including ourselves, manage to elaborate themselves into the complex, specific forms we find in the organic world remains, for all new factual knowledge, still a profound mystery and the most intriguing theoretical problem in biology. Other inquiries may currently prove more fruitful as they draw upon the already well-developed sciences of physics and chemistry, but eventually we have to meet the challenges of morphogenesis by forging new concepts to embrace within human understanding the unique phenomena of development.

Naturally no book today can do this for us and we should be satisfied with personal

orchestrations of selected data to which good minds have devoted their best thoughts, urging always closer to a future "break-through" in our comprehension of morphogenesis. Such is the present volume which is perhaps also the summing up of a life-time's study by the distinguished McGill zoologist.

Berrill's work is notable in drawing our attention to the amazing performances of "simpler" and less well-known forms than starfish and amphibia—coelenterates, worms of several phyla, and tunicates, including colonial animals in which the resemblances to plants is most striking. There are in fact two chapters summarizing our knowledge of the development of the vegetative shoot and the floral apex. Although these discussions cannot go far in revealing fundamental differences and similarities between plants and animals, their inclusion is a worthwhile effort toward integration of approaches to morphogenesis and intriguing parallels are discovered. These have to do with the relationships between growth and form on which Berrill is especially good, correlating growth phases and size of embryonic fields with morphogenetic events.

Since theory lies still in the future, Berrill sticks close to the empirical, and his presentation of selected types—Acetabularia, Stentor, Volvox, Dictyostelium, Hydra, certain jellyfish-hydroids, tube worms, flatworms, sea squirts, etc.—is precise in detail and augmented by a series of 252 excellent drawings. Yet in a central chapter Berrill achieves an outstanding set of first-order generalizations unifying his most varied material—both plant and animal—and these will no doubt provide a very useful guide to later theory. The theory he envisions as emerging would postulate a cell surface pattern as the basis of unicellular morphogenesis, evolving a trans-cellular cortical network in multicellular organisms, necessarily in addition to what biochemical and genetic analysis reveals, intimately correlated with growth, and guiding the otherwise mysterious and paradoxical transformations in the development and regeneration of organic forms.—VANCE TARTAR, University of Washington.

Manual of Vegetation Analysis. By Stanley A. Cain and G. M. de Oliveira Castro. xvii + 325 pp. 45 figures. 74 tables. Harper & Bros. New York. 1959. $7.50.

In the preface Dr. Cain writes of the intention of the authors to prepare "a small manual of concepts and methods" that might be of value to the National Malaria Service of Brazil and of the growth of the scope of the manuscript "beyond the original intent". Perhaps the title of the work should have been changed to conform with its extended scope. This book is certainly more than a "Manual of Vegetation Analysis". However, its central interest lies "in the application of phytosociological concepts and methods, most of which had originated in the north temperate regions, and had not yet been well tested under tropical conditions in Brazil".

Manual of Vegetation Analysis, "restricted to techniques and problems of the physical description of vegetation", discusses floristics (with a criticism of the biotic province concept); community concepts and the synusial structure of vegetation and, in great and interesting detail, the nature of the tropical rain forest (with interesting comments on the monoclimax hypothesis of Clements in the light of strong persistent edaphic influences upon Brazilian rain forest vegetation). On page 104 it launches into analysis proper, dealing with standard methods of the day (single plot, multiple plot and plotless sampling), then turning to problems of abundance, density, frequency, dominance and the problems of sample size and "quadrat" type. Chapter 10 deals with the combination of community charcteristics (association tables, density-frequency-dominance indices, continuum synthesis, coverage-stratification diagrams, etc.). Synthetic concepts of presence, constancy and fidelity are dealt with in the next chapter while the final chapter deals with life forms and the slightly investigated leaf-size classes. There is a list of 425 references and an abbreviated index, through which one may move to the text to find further information concerning 86, only, of the 237 terms listed in the glossary.

The budding ecologist will find too little in the *Manual* that is helpful in assessing quantitative approaches or in judging sampling efficiency. The authors stress the need for the quantitative approach: on page 108ff the nested plot technique is set forth without reserve, on page 153 there is the barest hint of its possible unsuitability, and then on page 176 this technique is inconspicuously blamed for a gross underestimation of the total flora of a stand investigated by Evans and Cain. The authors note that "the ultimate test of any methodology is its usefulness for the purposes at hand, including its relative efficiency"; on page 121ff they set forth details for random distribution of sample plots and for regularized distribution of such plots, but without a word concerning the comparative values of the methods; on page 133 the simple statement is made that "where practicable a random sample is to be preferred". But is it? The merits of systematic versus random sampling are still under discussion, with considerable evidence of superiority of systematic sampling under certain conditions. The *Manual* makes no reference to studies such as those of Mesavage and Grosenbaugh (J. Forestry, 54: 569–576, 1956). Quantitative ecological studies of to-day must be subjected to the searching light of statistical criticism but the inexperienced worker will not be made statistically wary by perusing the *Manual*. He would be well advised to place beside it a copy of P. Grieg-Smith's *Quantitative Plant Ecology* (New York. Academic Press, 1957.).

Although the printing is of high quality, with figures and tables of adequate size and clarity, a definite lack of polish characterizes the *Manual*. It is not restricted to the almost inevitable typographical and proof-reading errors or the strange reference to *Selaginella* as a fern but extends to various tables and figures lacking appropriate literature citations. The uninitiated will certainly have trouble with the density percentages of page 196. Omission of one varzea species from Table 7, together with a confusion of ratios and incorrect species totals in the accompanying text, does not suggest polish. A map with the Brazilian place names used in the text would have made a useful end-paper, particularly in the light of the fact that the *Manual* is more than a manual, presenting at least 16 tables and figures and much text material dealing with hitherto unpublished data from the Brazilian studies of the authors.

This review is not written by an ecologist but by a botanist exploring the field of plant ecology. Leaving aside the question of polish and the inadequate treatment of quantitative problems, there is much of great interest and value in the *Manual*. Reference will be made to a few items only. Raunkiaer's law of frequency is considered in some detail, with the effect of quadrat size set forth, the discussion leading to "the conclusion that a close fit of data to Raunkiaer's law of frequency is no real measure of adequacy of sampling, nor is it of itself an adequate measure of the homogeneity of a community". Preston's analysis of the law of frequency in terms of a Gaussian distribution of the species in an ecological assemblage is also set forth in considerable detail. There is a good discussion, tied into Preston's data on the commonness and rarity of species, of the usefulness of plotting of species-area data on semilogarithmic paper, to estimate the number of species present in a given area of a partially investigated community.

Dominance is given far more than the conventional treatment, the consideration of physiognomic dominance being particularly interesting, not only as it relates to obviously closed communities but to "open" communities where nonetheless the subterranean living space may be fully occupied and ecological dominance thus expressed in spite of superficial appearances to the contrary.

There is an interesting treatment of fidelity, with adequate justification for the statement that "In general, the farther one goes geographically from the location of a particular study, the less fidelity have 'fidelity data'."

There is an extended treatment of life forms with comparative data that indicate the wisdom of using measures of cover as well as species lists for the construction of life-form spectra. A similar treatment is suggested for leaf-size spectra.

Possibly the greatest value of "Manual of Vegetation Analysis" lies in the clear way in which the authors indicate the inadequacy of various temperate zone approaches for analyzing tropical vegetation. They analyze very carefully, for instance, Katz's con-

cept of homologous series of twin associations and its usefulness for expressing floristic and ecological relationships when applied in an area poor in species and with a rigorous environment but they show that it can not have value as a system of vegetation classification in a region rich in flora. In their consideration of stratification in tropical rain forests and the use of profile diagrams they point to the need for distinguishing transgressives from life-form groups to demonstrate any fundamental stratification that may exist. The book as a whole points up the complications of tropical vegetation and the need for exercising skill and imagination in designing methods of analysis suitable to the individual research area and problem. It may be that the most useful treatment of tropical vegetation is one that puts "considerations of microenvironment and of succession and climax . . . in a secondary position" while these considerations loom increasingly large on sites of vegetation analysis progressively removed from the tropics towards the poles.—A. N. LANGFORD, Bishop's University, Lennoxville, Quebec.

Laboratory Studies in General Botany. By William M. Carlton. vi + 428 pp. 309 figs. The Ronald Press Company. 1961. $4.50.

Carlton and The Ronald Press Company have produced an exceedingly fine manual for the laboratory work of a conventional course in general botany, and at a reasonable price. It is conventional in starting with "The Plant Kingdom—A Survey", followed by the Angiosperm plant as a whole, the seed, germination, the microscope, cells, tissues, cell division, and then five exercises in plant physiology precede the study of organs. Those who prefer to study organ structure before function may change the sequence, of course, but most of this is cellular physiology, a fact which we sometimes overlook. In all there are 29 exercises based upon higher plants, including heredity. Then begins the usual survey of the plant kingdom followed by taxonomy of Angiosperms, ecology, plant geography—one exercise each—a total of 51 exercises.

Spiral binding permits full opening and flat pages for easy reference and for writing. The instructor is then faced with the decision about grading. The author has grouped illustrations and pertinent questions are the end of each exercise. Shall the instructor ask the student to mutilate his book by tearing these out to hand in or shall he retain the manual in the laboratory and turn to the exercise for grading? The author suggests that students "read through the assigned exercise or exercises several times before coming to the laboratory." My experience is that frequently questions get answered and drawings get labelled in the course of this reading. The result is a slighting of manipulation and observation in the laboratory.

The experiments and observations are largely those that the instructor will have done several or many years ago. The Sachs chain is there, with no mention of Sachs. There are no equations representing photosythesis or respiration, which is commendable. The equation $Ba(OH)_2 + CO_2 \rightarrow BaCO_3 + H_2O$ is misleading at least and at one point the author directs, "bubble this gas through a container of barium hydroxide." Another careless statement refers to a colloidal system as a "solution." It would perhaps have saved numerous people disappointment if the experiment placing *Elodea* under a funnel in anticipation of collecting and identifying a gas had been omitted.

On the credit side is an exercise on soils, one on vegetative reproduction, and one called "Nature and Classification of Fruits." Instructors will differ in their reaction to these exercises and the one on Plankton, particularly to some of the experiments in them, but they add to the completeness of a course in general botany where the environment of the living plant is considered. A most commendable characteristic of the manual is the fact that students are directed to do something about what they study. Many ways of taking and recording data are employed. Where drawings are provided, which is most of the time, they are excellent. Questions in the experiments deal with the manipulation going on, while those at the end of the exercise often require more application, interpretation, and/or supplementary information. Another useful characteristic is a tabulation of page references for each exercise to nine of the commonly used textbooks. —JOHN A. SMALL, Douglass College, Rutgers, the State University of New Jersey.

The Plant Community. By Herbert C. Hanson and Ethan D. Churchill. xii + 218 pages. Illus. Reinhold Publishing Corp. 1961.

Upon reading the Foreword by Peter Gray, the Preface, and the Introduction to this book I was impressed with the likelihood of a new and refreshing approach to the subject matter of plant ecology. The table of Contents bore this out. There is no division of the text into characteristics of the organisms and characteristics of the environment. Plants and plant communities are of course the product of the whole environment and that concept is held to from cover to cover.

After reading the book I am uncertain about the desirability of this approach. To find out what the authors have to say about the relation of the plant or plant community to soil, one must read the whole book or go through the index carefully. The same is true of other environmental factors. Is this good? It certainly supports the statement in the Preface: ". . . the authors have adopted as the central theme of this book the formation and nature of the plant community" (p. ix). Is that enough for a course in plant ecology? The "relations of species to the physical environment" (climate, soil, topography) occupys 19 pages of which at least six are taken up with charts, pictures, and tables. Mostly the factors are applied in a discussion of ecological amplitude. But these factors recur in subsequent discussions particularly those dealing with dynamics and classification of plant communities. So the approach may be desirable.

The instructor using this text will have much supplementary work to do, not in supplying factual material but in supplying enthusiasm for the subject. The definitions, facts, terms appear to be quite complete but they are only that with some examples and illustrations. The subject does not come alive, yet what is more alive than a plant community? One would expect two eminent plant ecologists to have used and evaluated several methods of community analysis and measurement. Nevertheless the quadrat method, while receiving the most discussion is limited to grassland in its treatment, which is inadequate. The authors then list seven methods, also for grassland only, and state, page 103, "The methods have been described in numerous publications and summarized and evaluated in a few." Citations are then indicated to a paper by Dorothy Brown which should be complete (223 pages of methods) and one by the senior author which surely has very little space devoted to methods. Both papers are based on grasslands. One can understand the interest and recognize the competence of these men in the grassland biome but should an author not overcome his provincialism?

This provincialism sometimes fouls up the use of terms as well as methods. Basal area is introduced on page 102 and rather thoroughly discussed but there is no indication that trees have basal area which is commonly used in the analysis of such communities. The tables are generally informative but the stand table (Table 3–1, p. 117) falls short of this in that the "No. of vascular spp. per m^2" appears to vary frequently from that indicated. In class this table could lead to an interesting discussion of the relative merits of the Hult-Sernander scale (for which no reference is cited) and estimated percentage as a means of evaluating cover importance.

There is a rather generous use of photographs but either the authors' selection or the publishers' reproduction leaves much to be desired in too many cases.

There is commendation due as well as criticism. The discussion of succession and climax in chapter 5 titled "Habitat pattern, changes, and climax" deserves full commendation in my opinion. Many an instructor may use it as a basis for prolonged discussion of climax, particularly, but when it is over the concept of climax as the present authors present it is quite likely to be the one taken away by the student. It may not be too clear without field experience and further study but it will be meaningful and useful.

The bibliography contains 213 titles and it is to be hoped that the students will make reference to a great many of the citations. I found the index satisfactory and useful since cross referencing was more or less required at times—about environmental factors and methods, for instance.

The authors have provided what they promised in the Preface and the book will fulfill the uses which they anticipated.—JOHN A. SMALL, Rutgers, The State University of New Jersey.

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INDEX TO AMERICAN BOTANICAL LITERATURE

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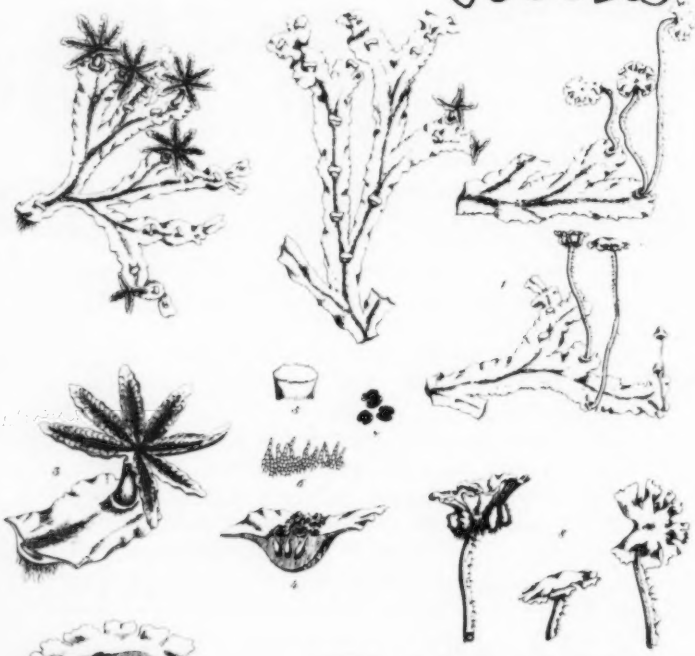

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